COUNTRY PLUMBING PRACTICE

WILLIAM HUTTON

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COUNTRY PLUMBING PRACTICE

DESIGN, INSTALLATION AND REPAIR OF SYSTEMS OF WATER SUPPLY AND SEWAGE DISPOSAL FOR COUNTRY AND SUBURBAN BUILDINGS. TYPICAL INSTALLATIONS OF PLUMBING WORK IN NEW AND OLD HOUSES

By WILLIAM HUTTON

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DAVID WILLIAMS COMPANY
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INTRODUCTORY

The provision of an ample supply of water and means for the removal of the wastes from all residential, public or business buildings is now universally required. While these requirements are more or less easily met in cities, conditions are different when the buildings are located in suburban or rural districts. Then it may be necessary to install a power plant, even if a simple one, to raise water to the desired levels, and also a plant which will dispose of the organic wastes resulting from the occupancy of the buildings without creating a nuisance or a menace to the health of the occupants or residents in the vicinity.

It is the purpose of this book to offer some assistance in designing and installing the various appliances necessary for the supply of water by gravity or mechanical power and for the disposal of sewage and kitchen wastes by the biological process. The maintenance of the appliances in proper repair has also received consideration and it has been the intention throughout to arrange the subjects treated in a manner which would appeal to the men who are most likely to require assistance,—the plumbers who are called upon to install or repair any of the hundred and one appliances which the requirements of local conditions may entail.

It may be taken as an axiom that what is good plumbing in a city is good in a country house or in a building in a provincial town. At the same time, owing to the smaller number of fixtures employed it is quite possible to simplify much of the plumbing work in such buildings while maintaining a perfectly satisfactory quality and perfectly sanitary conditions. In the design of plumbing construction in various types of buildings these conditions have received full consideration and the simplification of the systems of waste and vent lines has been advised wherever possible. The examples selected have been taken from the designs of installations actually made. Much of the material has been prepared from descriptive articles which have appeared in *Metal Worker Plumber and Steam Fitter* and several have been installed under the personal supervision of the author.

It is hoped that the principles underlying the various divisions of work treated have been made clear so that the reader will be able to apply them with assurance of satisfaction in installing work of a similar nature. No attempt has been made to cover the complete equipment of all types of buildings coming under the various heads as it is apparent that repetition would have been inevitable. Rather has it been the aim to illustrate and describe simple and safe means of effecting the desired results, with the knowledge that the principles laid down would enable the student to elaborate on the methods shown if necessary.

If the book proves to be of assistance to the man who desires to install work with expedition and satisfaction to his clients or to repair any of the mechanical features of country plumbing effectively it will have served the purpose for which it was written.

Wm. Hutton.

CHAPTER I.

ENGINES USED FOR WATER SUPPLY SYSTEMS

The power generators in general use for water supply purposes are gasoline, steam, hot air engines, steam pumps, windmills, hydraulic rams and turbines. Electric motors are also commonly used where current is available. Of all, probably the most commonly used is the gasoline engine and this will be taken up first.

Engines may be divided into two classes and these classes may again be sub-divided. For the purposes to be illustrated however the general classes are sufficient and are those in which the combustion of the fuel takes place outside of the cylinder and the heat is transmitted through some medium to the point where it is converted into work and those where the combustion of the fuel and the conversion of the resultant heat into work take place directly at that point.

Engines of the former class are called external combustion and the latter internal combustion engines. Steam engines and pumps and hot-air engines come under the first classification, gasoline, kerosene and all gas or heavy oil engines under the second. Gasoline or kerosene as fuels for the internal combustion type are the most convenient to use and the most extensively adopted for country residence work. Although either of these fuels may be used with success as the indirect source of power, for instance as the fuel for burning in the furnace of a steam boiler or hot-air engine, the greatest efficiency is secured by their use in internal combustion motors. The reason for this can be shown easily enough.

In the steam engine, which is the most efficient of the first class, a large proportion of the heat produced by consumption of the fuel is lost by radiation from the plates of the boiler, and in the flues and chimney. It is calculated that not more than 20 per cent. of the total heat available from the fuel is converted into work by the engine under the most perfect conditions and this loss cannot well be avoided. The difference in temperature between the products of combustion on one side of the plate and the water on the other is very great (some 2000 degrees F. against 300-400 degrees F.) and cannot well be equalized. Even at a boiler temperature of only 400 degrees F. the pressure is higher than it is generally considered safe to carry. It stands to reason therefore that a large percentage of the heating value of the fuel must pass to waste and that the fuel utilized must of necessity cost less than that used in an engine of higher efficiency else the operating costs will be excessive.

In a gas or gasoline engine the necessity of passing the heat from the products of combustion through any intervening medium is avoided. Burning the fuel directly in the working cylinder produces there a temperature of some 2000 degrees F. and therefore a much greater proportion of the heat can be converted into work than in a steam engine, while the means that are used to utilize the power produced are simple and direct.

The best class of gas engine has an efficiency of about 40 per cent. but the small and cheaply constructed type of engine more generally employed for pumping work may only average 15 to 20 per cent. The Diesel gas engine, using crude petroleum will convert about 35 per cent. of the available heat units in the fuel into work. These figures do not seem to show any great advantage in efficiency over the steam engine but in actual practice the results are superior without question. However that may be, a steam engine may easily be the more economical if the cost of fuel is low, if the attention entailed does not call for extra cost and if the work is continuous. Likewise a hot air engine may be the most suitable when only light work is to be done or when those handling it are devoid of any mechanical ability but for general handiness and efficiency and readiness for action at any time the gasoline motor may be said to head the list.

In addition to its regular work in raising water the gasoline engine possesses the additional advantage of portability when desired. A small motor mounted on skids in such a manner that it may easily be detached from the pumping machinery and used to saw wood or turn the separator or other machines around a farm offers a strong inducement to the farmer to invest in it and many a plumbing installation and water supply system have been constructed which would not otherwise have been put in if this feature had not been emphasized.

Factors Determining Choice of Power Generator.

When the choice of a power generator lies between a steam engine and an internal combustion motor the factors to be considered are these:

1 Location—for convenience of attention and provision of fuel.

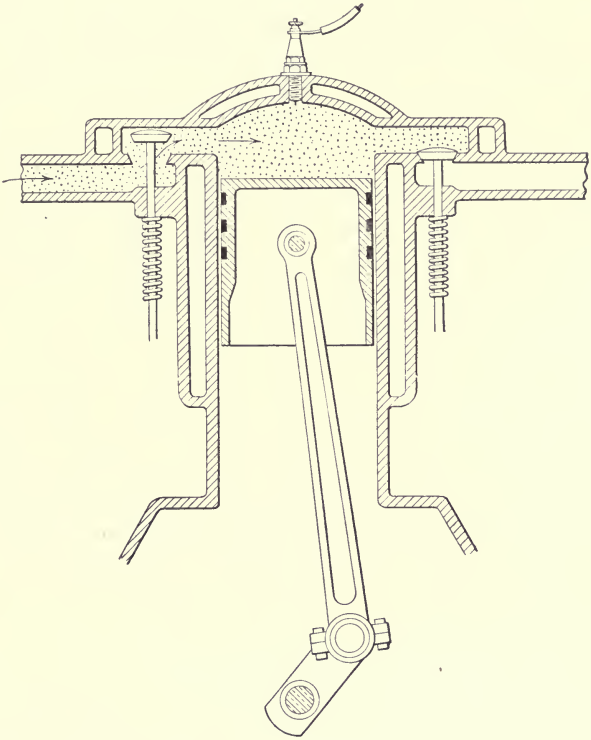


FIG. 1—FIRST OR DOWN STROKE OF FOUR CYCLE ENGINE
Inlet valve open—Exhaust valve closed

2 Comparative prices of fuel—wood, coal, versus gasoline or kerosene.

3 Nature of the work—whether constant or occasional and if load is intermittent or steady.

4 Cost of attention to power plant.

It will be found in most instances that the gasoline engine will make the best showing for small units of power, that for occasional work it is the most convenient and that the cost of attention is comparatively negligible as it is easily started, will run for long periods without attention and does not require special training to handle. Hot air and steam engines have their special fields. The conditions under which their use is economical or desirable will be dealt with later.

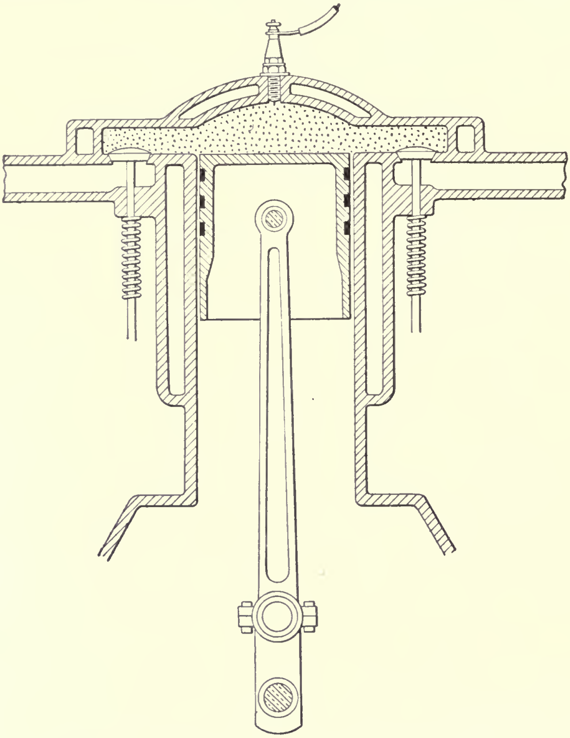


FIG. 2—SECOND OR RETURN STROKE OF FOUR CYCLE ENGINE
Both valves closed—Gas being compressed

Types of Gasoline Pumping Engines.

The engines generally used in pumping work of the class which comes under the scope of residence water supply are simply constructed as a rule and are almost invariably built on an interchangeable basis so that parts for repair may be conveniently secured with the assurance that they will fit. The engines are of two types—the four-cycle or Otto type engine and the two-cycle type. The power necessary to supply water to the amount required depends of course on the height to which it has to be raised as much as on the quantity. It may be said however that the horse-power of water supply pumping engines will range from about two to ten horse-power and that the four-cycle engine will be used in the majority of cases, especially when the power is of the higher denominations.

In the four-cycle engine, as its name implies, four distinct operations are required to produce the power stroke. Beginning with the first or down stroke of the piston which takes place simultaneously with the opening of the inlet valve from the fuel container, or which, if the valve is automatic, (opening by suction), is the cause of its opening, the cylinder is filled with an explosive mixture of air and atomized gasoline. The return stroke is made with both the inlet and exhaust valves closed so that before the

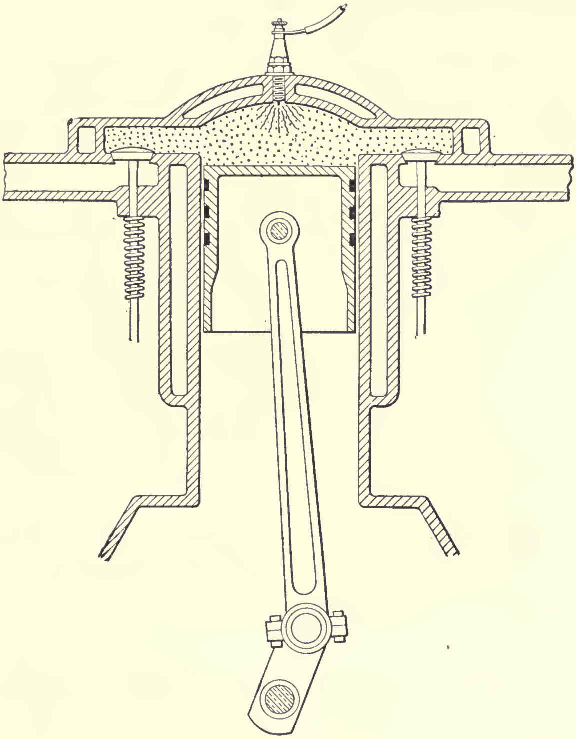


FIG. 3—THIRD OR POWER STROKE OF FOUR CYCLE ENGINE
Both valves closed—Gas being ignited

piston has reached the end of the stroke the contents of the cylinder have been compressed to a fraction of their atmospheric volume. This compression is attended by a rise in temperature and is consequently limited to a definite amount.

Immediately before the piston has reached the end of the stroke the gas is ignited by automatic means and the sudden expansion which takes place in consequence is the source of the power which causes the piston to travel back on its third or power stroke. Its return on the fourth and last stroke of the cycle is accompanied by the opening of the exhaust valve so that the burnt gases are swept out as the piston moves to the end of the stroke. Thus the cylinder is cleared of the products of the combustion of the explosive mixture and the following first stroke re-charges it with fresh gas which is compressed and ignited as before. Thus the consecutive

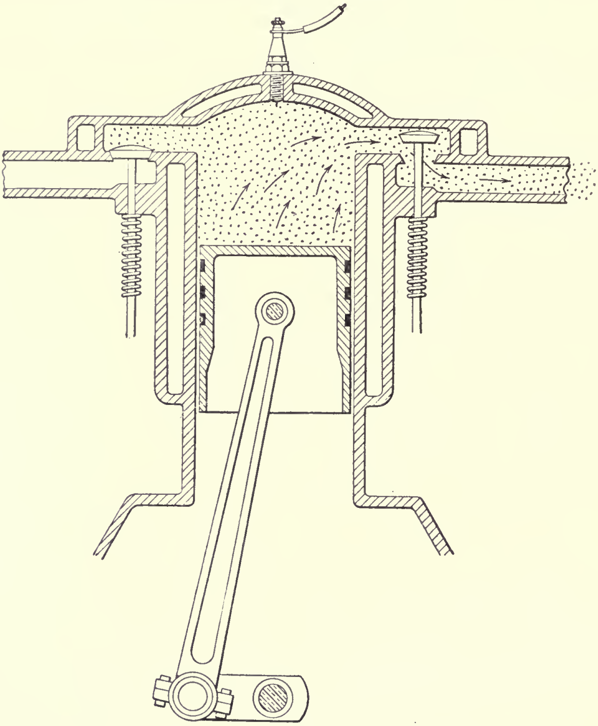


FIG. 4—FOURTH STROKE OF FOUR CYCLE ENGINE
Exhaust valve open—Burned gas being swept out

operations of suction, compression, ignition and dispersion continue so long as the fuel supply holds out or the mechanical details of the engine continue in proper condition.

The four positions of the piston and crank on the various strokes are shown in Figs. 1 to 4.

In passing it may be said that the "stroke" of various engines differs. That is, the space through which the piston is caused to move varies in different types of engines. The rule is that a slow running engine has a long stroke and a smaller diameter of cylinder than an engine designed to run at high speeds. The average compression in gasoline engines is about 60 lb. per sq. in. and the pressure raised by the explosion of the gas in the cylinder is about 4½ times that amount so that a force of about 270 lb. per sq. in. is exerted on the piston head at the commencement of its power stroke.

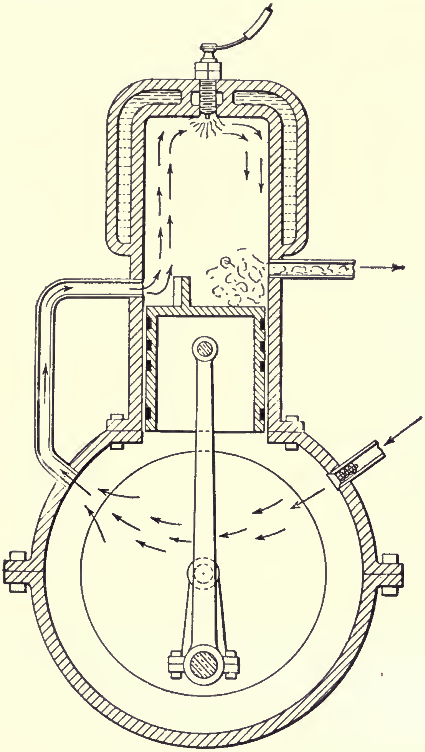


FIG. 5—TWO CYCLE ENGINE ON DOWN STROKE
Gas exploded, piston forced down, drawing fresh gas from crank case

The two-cycle motor, instead of having a power stroke only once in two complete revolutions of the crank shaft, has one each revolution. The piston itself controls the admission and exhaust of the gases through ports which are covered and uncovered as it moves in the cylinder and each stroke performs two distinct operations as will be understood from a reference to Fig. 5. The crank case is made gas tight and the mixture of gas and air enters through and is retained by a small valve in it.

When the explosion takes place on one side of the piston the other in its descent partially compresses the gas in the crank case. A further descent uncovers a port and the partly compressed gas rushes into the cylinder. On the return stroke the rising piston fully compresses the gas now in the cylinder and at the end of the stroke ignition takes place. The piston on the other hand does not sweep out the burned gases as in the four-cycle type, these escaping by virtue of the pressure generated in the explosion at the completion of the power stroke. The entrance of the fresh charge at this point in the cycle also helps to displace all the products of the combustion of the previous charge.

As in the case of the four-cycle engine there are many modifications of the two-cycle principle introduced in the construction of these motors. Among these may be mentioned special cylinders in which the gas is compressed instead of in the crank chamber. In this case the fresh charge is transferred to the combustion chamber of the engine without the necessity of passing into the crank chamber and the ports are placed differently to admit of this.

Two-cycle engines are largely used in motor boat work owing to their freedom from vibration but as they are not so economical of fuel as the four-cycle type the latter is more popular for stationary work. Four-cycle engines are manufactured in two styles, horizontal and vertical, these terms being descriptive of the movement of the piston in its cylinder in relation to the base line.

The principle remains the same throughout the many modifications in the two styles and any mechanic who studies and thoroughly understands one or two types with mechanical details differing in action while similar in effect will have no trouble in understanding any make with which he may come in contact. For this reason the details of one or two of the better known engines will be described, these being selected solely to show the different application of mechanical principles common to all.

CHAPTER II.

MECHANICAL DETAILS OF GASOLINE ENGINES

The principal parts of a four-cycle gasoline engine may be said to consist of a cylinder cast as a part of the water jacket which surrounds it or separately as the ideas of the maker may dictate, a piston fitted with expanding rings to secure a close fit in the cylinder with the least amount of friction, valves set and actuated so as to control the admission and exhaust of the explosive and burned gases, means of atomizing the gasoline and regulating the mixture with air to the required proportion and means for the transmission of power from the piston to the shaft.

The construction of the parts is not involved and need offer little difficulty to any mechanic in understanding the utility of each or in making replacements of worn or broken pieces. The parts most likely to require attention periodically are the valves, piston rings, carbureter and ignition device. The rings are generally made of cast iron and are cast of unequal thickness so that they will not be liable to movement in the cylinder which would bring all three of the joints into alignment. Should this occur there would be a loss of compression and consequently a loss of power, with an attendant heating of the crank case by the escaping gases. The rings may also be made in various styles with this same end in view and in replacing the piston when it has been removed for any reason it is important that the rings be placed properly in relation to each other and to the groove into which they are fitted.

The valves on gasoline engines are almost invariably of the mushroom or poppet type and the operation is peculiar to this style of engine. The exhaust valve is always operated mechanically but the inlet valve is very often operated by suction and is then known as an automatic valve. When this style of valve is used it opens on the first stroke of the engine by reason of the vacuum created by the downward motion and to ensure its return to its seat at the completion of the stroke a spiral spring is provided which surrounds the spindle of the valve and which is caused to compress against a washer or cotter pin attached to the end of the spindle. The valve may be fitted to a special box at the side of the cylinder or into the cylinder head according to the design of the engine. Fig. 6 shows a valve of this type which is used on a horizontal engine. It will be seen that it is fitted into a cage which is easily removable. This is an advantage in re-grinding the valve seat and as will be afterwards explained this is necessary at intervals.

Both the automatic and mechanically operated types of valves are made with flat seats upon which the valve sits down against a ground face or with ground tapered faces and seats into which the valve head fits snugly. The relative position of an automatically operated inlet valve and a mechanically operated exhaust valve are seen in Fig. 7. The illustration shows why the alternate motions of the piston cause the inlet valve to open and close. The valve does not open on the third or power stroke because of the expansion of the confined gases by ignition but on the governing of the engine (which will be described later) many idle strokes are made, and to prevent waste of fuel through the opening of the inlet valve at each stroke and so allowing gas to enter and to be passed into the exhaust pipe unconsumed means are provided whereby the suction on the valve will be discounted. One way of accomplishing this end is to cause the exhaust valve to remain open during the time when the engine is running at too high a speed. Thus there is no vacuum produced in the cylinder when the piston makes its downward stroke and the inlet valve does not open. To prevent chattering of the valve however a still further precaution is taken. This is illustrated in Figs. 6 and 8 and consists of a rod attached to the exhaust valve stem and to the top washer controlling the spring on the inlet valve.

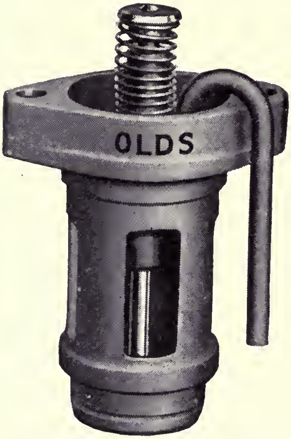


FIG. 6—AUTOMATIC VALVE AND CASE

As the exhaust valve opens it compresses the inlet valve spring and increases its tension so that the small amount of suction in the cylinder will have no effect upon it whatever. A sleeve on the rod permits of the free action of the inlet valve when the exhaust valve is operating without the control of the governor. The mechanical operation of an exhaust valve is also shown in Fig. 8. In this case the valve is caused to open through the movement of a lever actuated by cams and a rod. These are set to operate on the fourth stroke of the engine but are controlled by a governor so as to miss as many strokes as is necessary.

The engine illustrated in Fig. 9 shows the mechanical operation of both valves. In this case also the valves are operated by cams attached to a revolving shaft. The cams are set at such a position in relation to each other that they operate in raising the stem of the inlet valve on the first stroke and the stem of the exhaust on the beginning of the fourth. The shaft operating the cams is caused to revolve at half the speed of the crank shaft so that the timing is a simple matter effected by gearing.

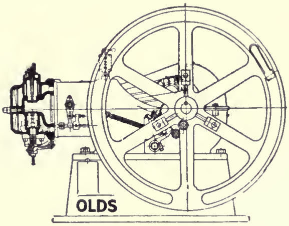


FIG. 7—DIAGRAM SHOWING LOCATION OF INLET AND EXHAUST VALVES

The closing of the exhaust valve is simultaneous with the opening of the inlet valve and the shape of the eccentrics or cams is such that both valves will be held open the right length of time to admit enough explosive mixture or to ensure a thorough sweeping out of the burned gases.

Thus the inlet valve begins to open with the beginning of the first stroke, is closed again at the completion, remains closed during the next three strokes while the exhaust valve begins to open at the beginning of the fourth stroke and is completely closed at the end just as the inlet valve begins to open again for the next cycle.

An alternative method of operating the valves is seen in some makes of engines where the valves are placed in the cylinder heads. Several variations on the mechanical details of this system are of course in use but the one illustrated in Fig. 10 shows the idea clearly. In the engine illustrated the valves are placed in cages. These are simply sleeves, the lower end of which are bored out to form a seat for the valve while the upper end forms a flange with which to bolt the cage to the cylinder head. This provision enables the easy removal of the valves for re-grinding or inspection. The valve stems pass up through the flange and the springs are held in compression by a flanged nut. The stems are depressed by rocking levers operated by rods connected with eccentrics mounted on a shaft which is driven by gears situated within the base and operated by the main shaft. The rocking levers cause the valves to open and close quickly at the beginning and end of their period. The motion is also quiet and smooth. The fulcrum for the levers is bolted separately to the cylinder head. This special type of valve motion is used only on engines of the higher grades but adaptations of it are common and the mechanical details not greatly dissimilar.

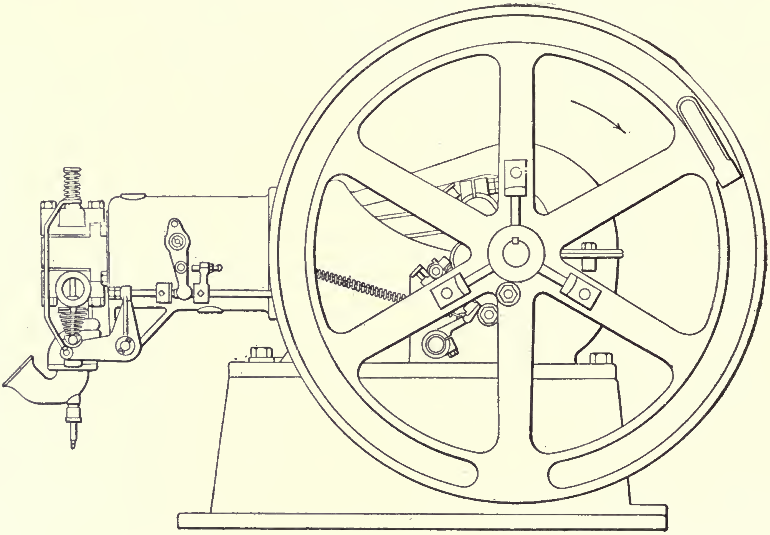


FIG. 8—DETAILS OF EXHAUST VALVE ACTUATING MECHANISM

How the Explosive Mixture is Produced.

Going back to the step before the entrance of the explosive mixture through the inlet valve, the apparatus which causes liquid to be transformed into a gas, or rather vapor, may be considered. The introduction of gasoline to a closed cylinder without an admixture of air would not result in an explosion and therefore the gasoline is atomized and passed into the engine along with a volume of air proportioned so as to ensure the most complete combustion possible.

The appliance utilized for this purpose goes by various names, carbureter, vaporizer, atomizer, but all are intended for the same purpose, and all effect the breaking up of the liquid into finely divided particles which lend themselves to an even mixture with the air taken in through the valve along with it, whatever the design may be. Perhaps as simple an arrangement as can be found is that seen on the small vertical engine illustrated in Fig. 11. From that illustration it will be seen that the suction of the piston on its down stroke lifts the gasoline from a tank to a small tube in which there is a ball check and thence into a passage controlled by a needle valve which allows as much to pass as is required to make

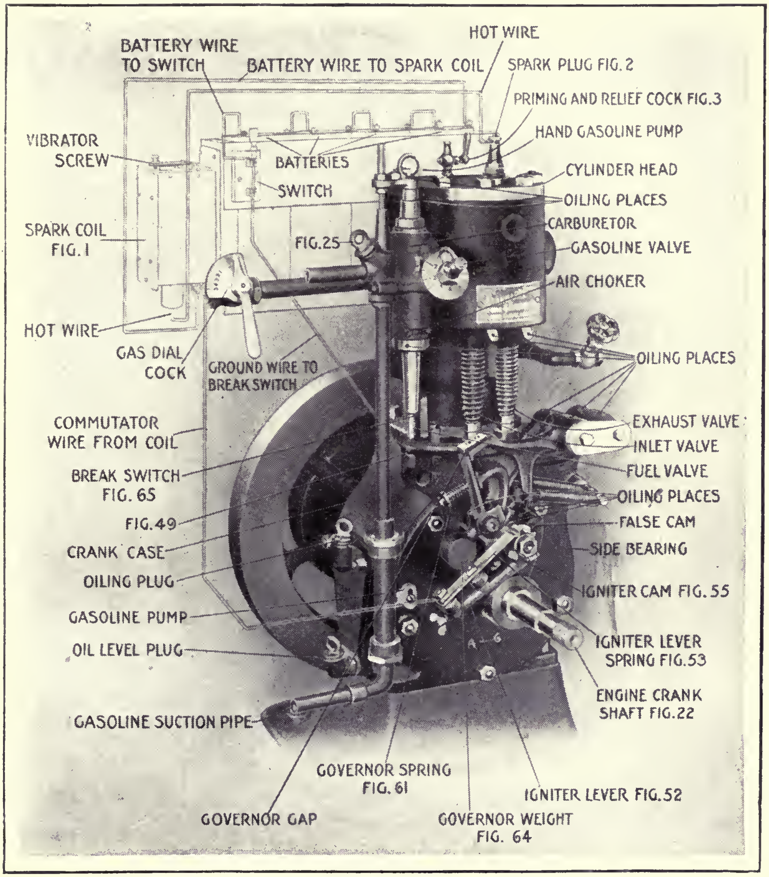


FIG. 9—DETAILS OF AN ENGINE WITH BOTH VALVES MECHANICALLY OPERATED

a mixture of the correct proportions. The shape of the mixing chamber is such that air drawn through a damper controlled inlet passes the gasoline outlet with considerable velocity and the liquid is picked up and broken into a spray before it enters the combustion chamber by reason of the deflection in its course.

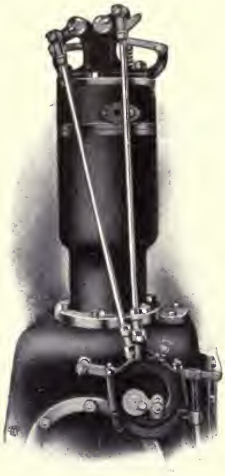


FIG. 10—VERTICAL ENGINE WITH VALVES IN CYLINDER HEAD

Another simple style of vaporizer and one that with modifications is in very common use is shown in Fig. 12. This vaporizer may be fitted so that the supply of gasoline comes to it by gravity or by a small pump. The level of the gasoline in the chamber is maintained in the first case either by a float or needle valve or by the suction of the engine drawing a small amount from the reservoir at each stroke, while in the second instance it is kept filled by the pump, an overflow being provided so that the excess supply is run back to the reservoir. The drawing of air at considerable velocity over the exposed surface of the gasoline in the chamber picks up sufficient in the form of a spray to form an explosive mixture but in some designs a further air supply is provided with a throttle so that any desired proportion of air and gasoline can be secured as required.

Still another style is shown in Fig. 13. This is a carbureter of the spray jet type and more nearly approaches in design the delicate apparatus used on automobiles. It is readily adjusted to provide a rich or weak mixture as desired by manipulation of the throttle on the air supply and the needle valve in the gasoline supply tube. The carbureter is set above the level of the gasoline supply reservoir and is kept filled by the piston suction or it may also be supplied by a pump. As shown the suction is depended upon to maintain a steady supply of gasoline and many engines use this system satisfactorily. The overflow back to the reservoir ensures the correct level of gasoline being maintained.

The suction of the piston besides drawing the gasoline from the reservoir also causes a thorough mixing of the vaporized gasoline issuing from the needle valve with the air. The shape of the passage from the air inlet to the supply connections to the engine is such that the air passes the jet at a very high velocity owing to the constriction at that point. After that it is lowered in velocity by the gradually increasing diameter of the passage, admitting of a thorough mixture before the inlet valve is reached.

These three types practically represent all that are in common use on small gasoline engines and any difference in detail is quickly apparent to the mechanic who is familiar with those described. The carbureter however is a very important detail of the engine and must be carefully tested to find the point at which the most complete combustion of fuel and maximum power is obtained. This point should be marked or noted to get the best results from the engine.

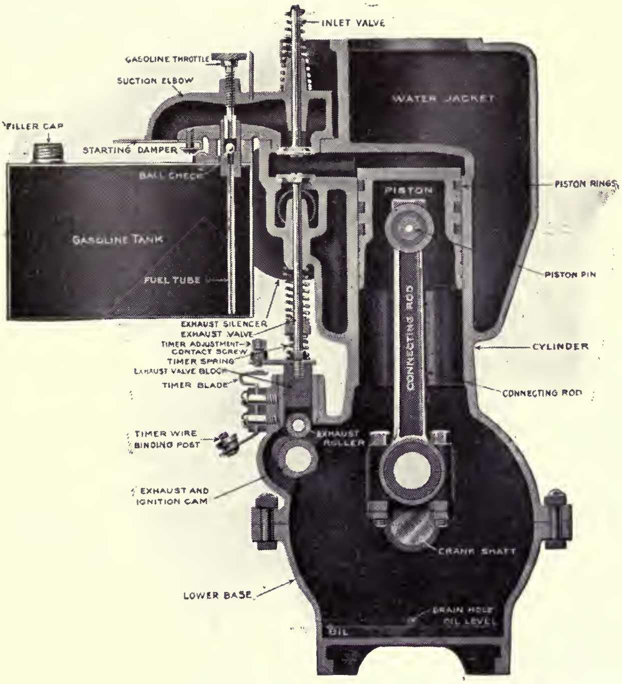


FIG. 11—SIMPLE CARBURETOR ON FAIRBANKS-MORSE ECLIPSE PUMPER

A pointer on the needle valve stem, a graduated dial or other means of showing the correct position of the needle valve is generally provided, and also as an aid to starting the engine some means of injecting fresh gasoline to the inlet valve or combustion chamber is frequently included. Thus in the type of carbureter depending on the pump to keep the level at the proper height, a hand pumping outfit, often consisting merely of a lever and means of quickly attaching it to the operating rod is provided.

By the aid of this the carbureter is quickly filled to overflowing before the wheel is turned over and an ample supply of gas at the first suction stroke is then assured. Sometimes a petcock is provided so that a small quantity of gasoline may be injected to the valve chambers before starting or the petcock may be in the combustion chamber and intended to be left open while a few turns on the starting handle are given to pump in a fresh mixture and to fill the carbureter to a proper working level.

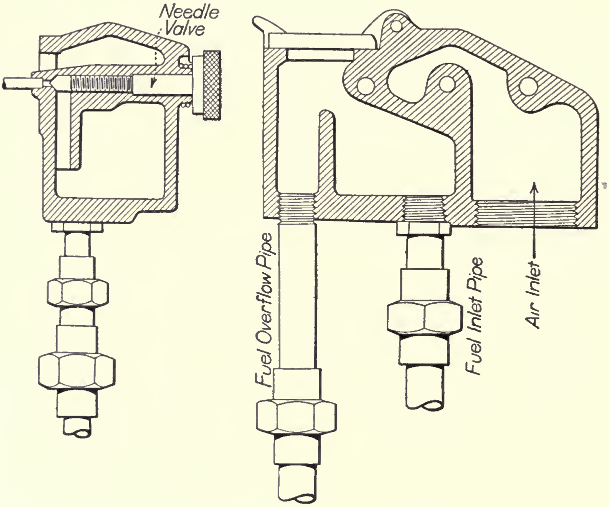


FIG. 12—SIMPLE TYPE OF VAPORISER FOR GRAVITY OR PUMP SUPPLY

Ignition of Gases.

The explosive mixture and the means of producing it and admitting it to the combustion chamber having been considered it will be in order to turn to the means used to ignite it and to time the ignition so that it will occur when the piston is at the correct position to receive and transmit the power generated by the expansion of the gases. This position is not, as many suppose, at the dead center or end of the compression stroke but a little before the piston has completed that stroke. This is termed giving the engine "lead" and the reason for it is that the explosion of the gases is not instantaneous and an appreciable time is required to develop the full pressure generated by the ignition, combustion and expansion.

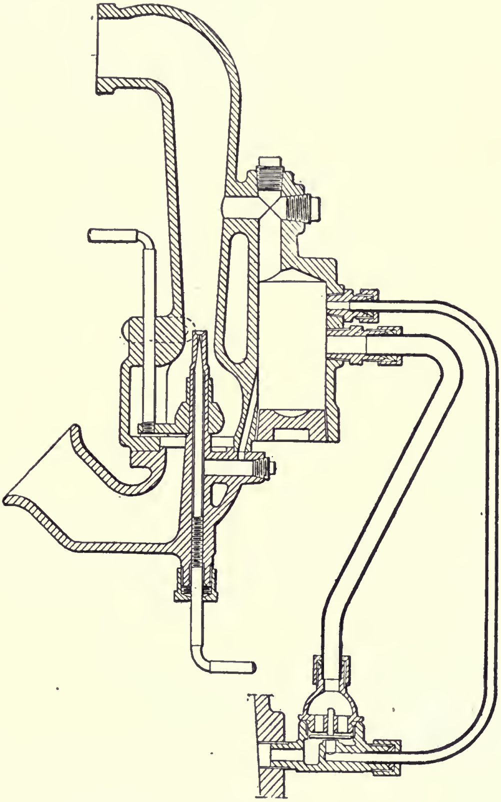


FIG. 13—TYPE OF CARBURETOR USED ON OLDS ENGINE

In automobile work this fact is taken advantage of to vary the speed of the engine. The point of ignition is varied by the rotation of the part which is caused to interrupt and close the electrical circuit so that the spark may be caused to take place a little earlier or later than the pre-determined ignition point as the driver desires.

Thus he is enabled to control the speed, as the farther the spark can be advanced without causing an excessive back pressure on the piston, the greater the expansion of the gases when the piston shall have commenced its downward or power stroke, and consequently the force exerted will send it down with greater speed. The later the spark occurs the less will be the total expansion of the gases before the exhaust valve opens and therefore the lower the speed and efficiency of the engine.

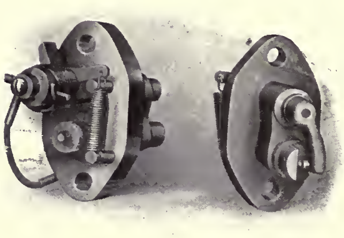


FIG. 14 FIG. 15

ELECTRIC IGNITER

On stationary engines this ignition point is not as a rule variable. The time of explosion is pre-determined to occur at the point where it will be most effective, and unless this has been changed through faulty assembling or re-assembling after repairs have been effected there need be no confusion arising from a misapprehension of this detail. The parts responsible for the fixing of the ignition point are marked so that anyone may take them apart and re-assemble them without trouble but this will be explained later.

Ignition may be brought about either by electricity or by what is termed a "hot tube." This latter device is not now commonly used although several makers fit tubes to their engines as an alternative system in the event of a temporary derangement of the electrical one. The hot tube consists of a tube made of nickel alloy, porcelain or iron, closed at one end and communicating with the combustion chamber of the engine. It is maintained at a full red heat by a Bunsen flame which plays on it inside a chimney surrounding it for the purpose of intensifying the heat. An explosive mixture being admitted to the cylinder, it is ignited by this tube, and on the following admission stroke part of the products of combustion retained in the tube are compressed into the upper end and the lower is filled with fresh gas.

The length of the tube and the position of the flame are adjusted so that the explosive mixture on compression will just reach the portion of the tube hot enough to ignite it, thus timing the explosion early enough to secure the full expansion of the gas in the combustion chamber. Too short a tube or heating improperly adjusted will cause too early ignition and consequent undue strain and wear on the engine which will be made known by "knocking." It may also cause back-firing, or inability of the momentum of the engine to overcome the expansion of the gases which takes place before the piston reaches its dead center, and this not only will stop the engine but will be likely to damage it.

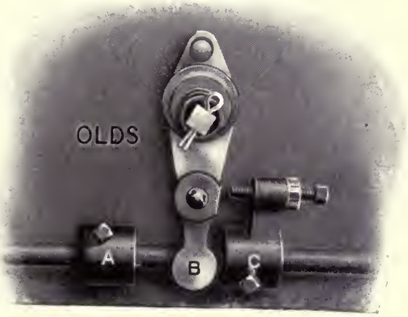


FIG. 16—ONE STYLE OF CONTACT MAKER

It will be seen that with this device the time of ignition is rather indefinite and the strength of the mixture and amount of compression is not variable with its use. A refinement in the way of a timing valve which is regulated to admit the explosive mixture at the desired time improves the appliance somewhat but it is never so certain in action or so easily cared for as electric ignition.

Electric Ignition.

Electric ignition provides an absolutely accurate system of timing the explosion so long as the mechanism is kept in proper condition and adjustment and no other factors such as overheating or undue deposits of carbon on valves, piston or cylinder heads are allowed to interfere with it. The method is to make a spark of sufficient size and temperature to ignite the gas passing between two points in the combustion chamber of the engine. This may be brought about in several ways and the methods may be divided into three separate classes, the "make and break," the "jump-spark" and the "magneto."

The first calls for a mechanical movement of two parts in the electric circuit which will break the circuit at the determined time and cause the current to form an arc between them. This mechanical movement is produced in what is termed a "make-and break-igniter," a removable plug generally placed in the cylinder head or over the inlet valve, by a rod which causes two platinum tipped points to alternately separate and come together. The current is conveyed by insulated wires and terminals on the plug to one of these contact points, the other being in electrical contact with the metal of the engine which serves as a ground. The prime source of the current is a battery of dry cells, or an accumulator or storage battery, and a coil. The positive connection of the battery is connected through the coil to the terminal on the igniter and the negative to some part of the engine. The coil is simply a bundle of soft iron wire around which the current is caused to flow in a coil of insulated wire. This intensifies the power sufficiently to produce a spark or flash of considerable size and heat at the points.

The spark occurs at the instant of separation and this of course is timed to occur when the piston is at the position best calculated to develop the full power of the explosion. The igniter plugs are of many designs, the motion of the moving parts classing them either as "hammer breaks," or "wipe breaks." A typical igniter plug is shown in the illustrations in Figs. 14 and 15, the first of which shows the outside and the second the inside appearance of the device. This is a plug of the hammer break type and the position of the platinum points on the rocking arm is seen in Fig. 15. The outside view shows the spring which is caused to close the points sharply when the tension of the operating rod or cam is removed. The terminal to which the electric wire is connected is seen in Fig. 14, the other point being in electrical contact with the earth or metal work of the engine as already explained.

The operating mechanism of the sparking device may be very simple and this is exemplified in the design shown in the illustration in Fig. 16. This is the operating rod on a horizontal engine and it will be seen that adjustment is made possibly by the sleeve which slides on the horizontal rod. By adjusting this and the small bolt with locking nut which passes through the arm on the sleeve the end of the bolt may be made to come in contact with the lever of the sparking device at exactly the moment when it is desired that the spark should occur. The sleeve on the opposite side ensures that the rocking lever will come back into the closed position on the reverse stroke of the horizontal rod should the tension of the spring not be sufficient to bring it back automatically.

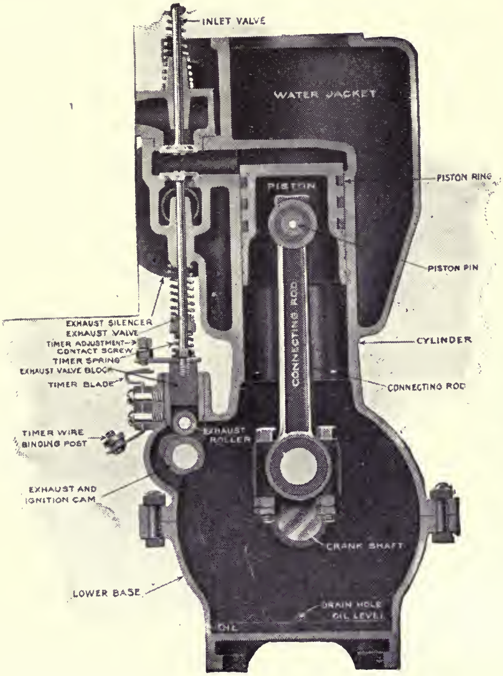


FIG. 17—A SMALL PUMPING ENGINE FITTED WITH A SIMPLE CONTACT MAKER

The jump spark style of ignition is designed along the same lines but does not require the movement of the contact points inside the cylinders; the coil is what is termed an induction coil and the points between which the electric current passes are stationary. The device which makes and breaks the continuity of the electrical circuit is fitted according to where the design of the engine makes it convenient. It need not necessarily be of a complicated design as is shown in the example of a make-and-break device operating the spark on a simple vertical engine in the illustration in Fig. 17. In this engine the exhaust valve is operated by a roller which in turn is caused to lift a block which bears upon the valve stem. An eccentric or cam on the larger roller seen in the illustration causes the roller to rise and come in contact with the block at the correct time but a flat side allows this smaller roller and exhaust valve block to drop a little at the time when it is desired ignition should take place.

The electrical connection is made by an arm attached to the sliding block. The arm bears a platinum point which comes into contact with a similar point on an insulated block attached to the engine frame. Insulated wires convey current to a terminal on this insulated block and so to the platinum point. Thus an arc is caused to take place between, not these points, but two similar points on a spark plug inserted in the valve chamber or combustion head of the engine. The points are readily adjustable as the upper platinum point is carried on a small bolt which may be moved up or down as desired.

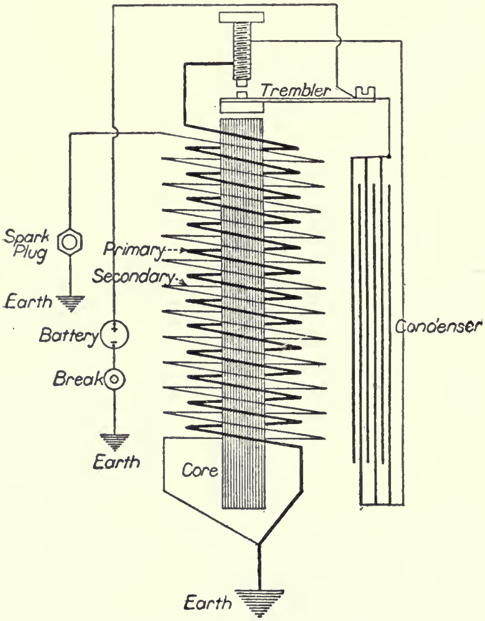


FIG. 18—DETAILS OF SPARKING COIL CONSTRUCTION

Another application consists in using a flat spring which is operated by the cam, this time outside of the crank case. Possibly this is the most common of all methods and needs no explanation as the operation is apparent at sight. A wipe contact maker consists simply of a revolving disc in which is a segment of metal in electrical connection with the metal of the engine. The rest of the disc is made of non-conducting material such as vulcanized rubber or hard fiber. The negative connection of the battery is grounded to the engine while the positive connection is connected with a terminal on a spring which is held in close contact with the revolving disc. This wire is of course insulated as is also the spring from the engine frame work and the result is that as the disc revolves the segment alternately opens and closes the circuit as electrical connection is established or broken. The making and breaking of the circuit in this way acts in creating an arc at a sparking plub as before described.

Induction Coils.

The induction coil used with this style of ignition is built upon the same principal as that described as in use with the low tension make-and-break ignition system but in addition to the coil of insulated wire surrounding the core of soft iron wire, a secondary winding of finer wire absolutely insulated first, and with no electrical connection with the battery, is required. This secondary winding is separated from the primary by a shell of vulcanite or fiber and is composed of a quantity of fine wire. When an electric current is passed through the primary coil for an instant only, an induced current of intensified power is produced simultaneously in the secondary coil. Generally speaking the more sharply the current is caused to flow and cease flowing in the primary circuit the better are the results obtained. To assist the production of a fat spark and to prevent excessive sparking at the make-and-break mechanism, such a coil is usually fitted with a condenser. This is simply a quantity of tinfoil in sheets interleaved with paraffine waxed paper for insulation and its function is to absorb a proportion of the electro-magnetic energy or self-induction of the primary circuit, the result being a fatter spark at the secondary terminals, that is the sparking plug, and a reduced pitting of the contact points.

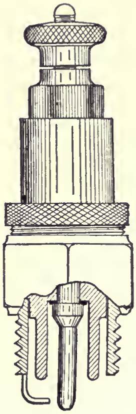


FIG. 19—COMMON TYPE OF SPARK PLUG

The secondary current is of much greater force than that in the primary circuit owing to the much greater number of turns made in the wiring or winding of the coil and it is generally spoken of a high tension current. It is this secondary or high tension current which is caused to produce a spark between the two points of the sparking plug in the cylinder of the engine.

An induction coil built as described will produce a single hot spark at each break or interruption of the primary circuit and a weaker spark at each "make" of the electrical connection of the points. The latter spark is not sufficiently hot to ignite the gases under compression in the cylinder but the spark passing at the interruption is hot and will ignite the gasoline vapor unfailingly so long as the points between which it passes are kept clean. Excess of lubricating oil and the use of too great a proportion of gasoline in the explosive mixture are likely to coat the points of the spark plug with carbon with the result that the spark will not pass the gap with the regularity required. Then misfiring of the charges occurs and explosions of gas in the muffler due to unburned gases passed from one explosion being ignited by the flame from the next.

A small attachment called a vibrator or trembler is now almost always attached to the coil. This device is intended to cause an extremely rapid interruption of the current passing in the coil, while the contact maker points are together or the spring is in contact with the segment of the revolving disc of the wipe-contact maker as the case may be. This vibrating interruption causes a steady stream of sparks to flow between the two points while the contact lasts. The sparks follow one another so rapidly that the stream has the appearance of being continuous so that ignition is much more certain. The vibrator consists of a small armature or disk of soft iron supported on a spring and mounted over the magnet core of the coil. When it is attracted by the magnetism in the core it presses down another spring which carries a platinum contact. This normally touches a platinum tipped screw but the moment the spring is depressed it breaks contact and stops the current in the coil and a spark occurs at the plug. Then the armature instantly springs back again and contact is again made at the platinum points, the current again flows and attracts the armature and another spark occurs. The action occurs with extreme rapidity, the speed being about 10,000 times per minute.

The vibrator is constructed in such a manner that at the instant the armature is attracted the interruption of the current does not take place but continues to circulate as long as will enable the core to be saturated with magnetism. The internal construction of an induction coil with vibrator or trembler and condenser is seen in the diagram in Fig. 18. The illustration is of course conventional and is intended only to show the arrangement of the coils and the various parts. The earth in this case is the framework of the engine, no wire being required to complete the circuit from either the spark plug or the contact breaker. The adjustment of the vibrator is an operation that must be conducted with care to secure satisfactory working of the coil. The proper method of adjusting it and of keeping the contact points in good order are described elsewhere in the book.

The sparking plug is a simple device of metal and porcelain, mica, or other non-conducting, non-inflammable material consisting of a shell or barrel which is threaded to fit a hole drilled in the combustion chamber of the engine or for which provision has been made in the valve box. Into the shell is fitted in such a manner that no leakage of gas is possible, a core of porcelain or other substance through the center of which passes a rod or wire terminating at one end in a point which stops close to the metal shell or body, forming a gap about ⅛ in. wide, across which the spark will jump. The outer end of the wire is attached to a small rod, threaded and fitted with two binding units, between which the end of the high tension wire from the coil is held fast. Many modifications of this plug are possible and hundreds of patents have been granted on inventions and improvements in construction designed to afford more certain sparking, ease of renewal of parts, lessening of short circuiting troubles and the like. A plug that is designed to avoid sooting or short circuiting by reason of the effective insulation of the central core and the shell, and also by the comparatively large amount of clearance at the points, is shown in the illustration in Fig. 19.

CHAPTER III.

SOURCES OF ELECTRIC CURRENT, COOLING, GOVERNING AND REPAIR OF ENGINES

The current necessary to produce the spark through the induction coil is obtained generally from a battery of five or six dry cells connected in series. Otherwise it may be obtained from an accumulator or storage battery of varying capacity. This latter device is commonly used on automobiles, as it is compact and will afford a hot spark for a time that can be very accurately calculated, while the life of a dry cell is rather indefinite. But dry cells are more convenient for the class of engine used in pumping work as they can be replaced easily and cheaply while it is not always convenient to have an accumulator re-charged when required. If the condition of the cells is tested with an ammeter now and again the probable life can be determined nearly enough so that a fresh supply may be available when the cells give out, or before they are too weak to give a spark that will ignite the charge.

Cells are made in several different styles and sizes but it must be remembered that the large size does not make it possible to use fewer cells in the battery. The increase in size only means longer life—or amount of current—but does not increase the voltage or pressure. Four cells will, however, be enough to produce a fat spark, as if they are in good condition each is equal to about 1¼ volts, and the voltage of a battery of four cells equal to from four to five volts. The increase in size of the cells of a storage battery or accumulator is likewise unaccompanied by any increase in the voltage although the capacity may be greatly increased.

An ammeter, or in full, amperemeter, should never be used to test an accumulator, as a rate of discharge much higher than the cell is designed to give will cause injury to the plates. This is shown by buckling and crumbling of the materials of which the plates are made. A dry cell differs in this respect that the rate of discharge is limited and the use of an ammeter on it is perfectly proper.

Magneto Ignition.

The magneto system of ignition calls for the generation of the current directly instead of by chemical action as in a battery of cells or using it from a storage battery. The result is the same, a spark is produced, but the method of producing it is different. This spark, or rather flash, for it differs in its nature from that produced by an induction coil, is given, when the ignition is on the low tension system from a make-and-break plug of the type already described, by electric current from a small dynamo of special construction. The armature of this dynamo is constructed so that a current is induced which rises to a maximum at each quarter revolution and the make-and-break mechanism is timed so that it will suddenly rupture the circuit of the armature coil at the instant the current therein has reached its maximum strength. This sudden rupture of the circuit causes the voltage or pressure of the induced current to rise considerably above its normal value and a flash occurs between the insulated metal pin of the plug and the moving finger.

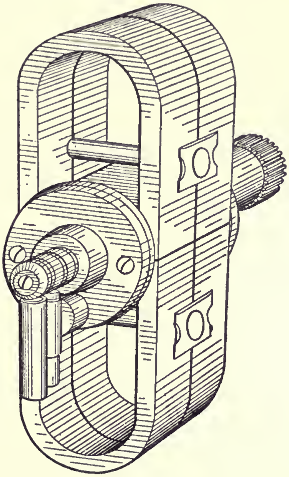


FIG. 20—MAGNETO COMMONLY USED ON GASOLINE ENGINES

When the engine is running at fair speed this flame has an intense heat and fires even a weak charge readily. The spark at low speeds is weak as the current induced in the armature of the dynamo is proportional to its speed. This is called low tension magneto ignition, a high tension magneto differing in that it requires the use of a spark plug of the jump spark type and a special winding of the armature is made to induce the higher power necessary to produce a spark on a plug of this type. The illustration in Fig. 20 shows a generator of this class used on many portable engines of the types suitable for general farm use as well as for pumping work.

The speed of the engine is regulated by controlling either the number of explosions or impulses per minute or by varying the power of the impulse while keeping the number per minute constant. The first method is known as the "hit-and-miss" method and the other the variable impulse system. The most common application of the hit-and-miss system is to provide a loaded bar on the flywheel which moves centrifugally in proportion to its speed. As it revolves it presses on a spring and as the centrifugal force increases and causes the spring to move backward the motion is transmitted to a rod or lever which breaks the electrical connection, thus preventing sparking at the plug and consequent ignition of the gas in the cylinder. At the same time it brings into action a latch which holds the exhaust valve open and as only atmospheric pressure can obtain in the cylinder while the latch is in this position the inlet valve does not open and no mixture is drawn into the cylinder. Should the inlet valve be mechanically operated it will keep on opening but the piston does not draw the gas in. There are of course many modifications of this system but that on the whole is the principle upon which all work. The centrifugal part of a hit-and-miss governor is shown in the illustration in Fig. 21.

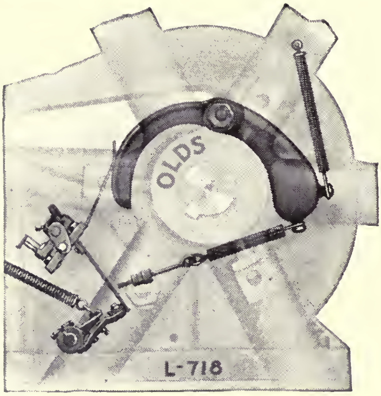


FIG. 21—THE STYLE OF GOVERNOR USED ON THE OLDS ENGINE

In the variable impulse system, centrifugal force is also called in to aid in governing the speed but it acts through the air and gasoline supply to the carbureter, varying the strength of the mixture from the weakest to the strongest firing limit by increasing or decreasing the air supply and also by cutting off the gasoline supply. It may also act by simply regulating the amount of mixture supplied to the engine without changing the proportions. The throttling of the inlet necessarily imposes more work on the engine as the piston moves out with a partial vacuum behind it and the decreased compression causes slower combustion, and therefore decreased power. The hit-and-miss system of regulation however is the one most commonly in use on engines of the type generally used in small pumping plants as it is simpler and cheaper to build.

Cooling of Cylinders.

All internal combustion engines require some means of dissipating the excess heat generated by the combutsion of the fuel. In what are termed air cooled engines the cylinders are cast with radiating fins which present a large surface to the cooling effect of the air and the excess heat is given up by these. To aid them it is usual to fit a fan which is caused to blow a current of cold air directly over the fins and so to carry off the heat. A more easily controlled method however is offered by water cooling. In this a jacket is cast integral with the cylinder in some cases or in others as a separate piece into which the cylinder is bolted. The jacket is filled with water which, as it absorbs the heat of the explosions, is caused to circulate to a tank which has a storage sufficient to provide cool water to replace it for many hours. A hopper which increases the storage capacity directly at the jacket and which obviates the necessity of circulating pipes is now commonly used and is increasing in favor. Where the waste of the cooling water is immaterial a connection may be made from the supply pipes and a stream be allowed to run through the jacket continuously.

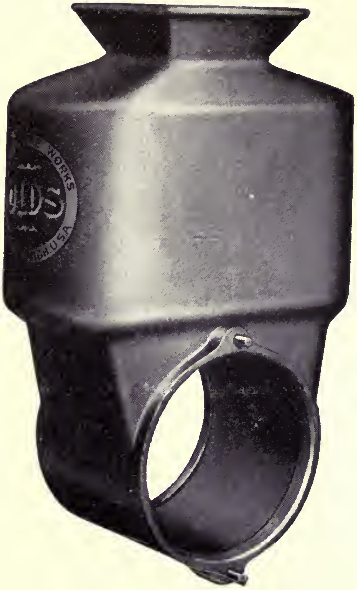


FIG. 22—HOPPER AND COOLING JACKET

It should be recognized that it is not necessary to have the water in the jacket cold. The best results will be obtained from the engine when the water is approaching boiling point so far as power production is concerned, but in practice it is desirable to maintain the temperature of the water in the jacket at about 180 degrees F. after the engine has been running some time. If the supply is adjusted to maintain this, the power of the engine will be satisfactory while there will be not excessive waste of lubrication. It is a good plan to fit a small pipe with a petcock or valve into the hopper if that style of jacket be used, so that a stream of water may be left running to maintain the temperature at the desired point and also to add water when it is necessary through evaporation. When this is done it is advisable to make a small overflow connection as well so that any water which might be added to excess will find its way to a point clear of the engine. In the illustration in Fig. 22 is seen a cooling jacket with hopper storage and the same jacket applied to a horizontal engine is seen in Fig. 23.

A jacket of an entirely different type both as regards construction and action is seen in Fig. 24. In this case a connection is made to one of the tappings and water is allowed to flow through the jacket directly from the pump. The inlet connection is at the bottom of the jacket and the outlet or overflow at the top while a valve on the supply pipe admits of regulation to any temperature it is desired to carry. In all jackets provision is made for draining in cold water and a plug is generally inserted at the lowest point so that it may be readily removed and the water allowed to drain out. It is also a convenient point from which to flush the jacket occasionally and this should be done periodically if the water happens to carry much sediment, or if it is of a nature which will deposit lime when brought to a boiling temperature. Trouble is often experienced through the latter cause when the water is of an alkaline nature and the deposit of any foreign substance on the walls of the jacket may lead to overheating through poor conduction of heat. Should this happen the piston might seize and damage the crank shaft or the connecting rod. In any event the jacket should receive attention from time to time.

Locating and Removing Cause of Trouble.

If the principle of a gas engine is well understood and its construction intelligently studied there need be little trouble in locating and removing the cause of a stoppage or a minor breakdown. There are however cases when the fault may be one of several which would have the same result and in such cases a process of elimination must be resorted to in order to reach the real cause and effect a cure.

There are three distinct heads under which gasoline engine troubles may be classed. These are Electrical, Mechanical, and Fuel Supply. The failures from each cause coming under one or other of these heads will probably show different symptoms; for instance a gradual stoppage of the engine would indicate trouble in the fuel supply, possibly a stoppage in the carbureter or exhaustion of the gasoline. If the engine were to stop suddenly the fault might be electrical or mechanical. While this does not always hold good it will in most cases, and therefore these heads may with advantage be kept in mind when trying to discover the cause of an involuntary stoppage. A number of the most common troubles and their probable cause are detailed in the following as a guide to the repair man. They cover most of the breakages and disarrangements due to wear and tear and also to careless handling of inexperienced attendants. As hints to the trouble man they will probably be acceptable and prove time savers.

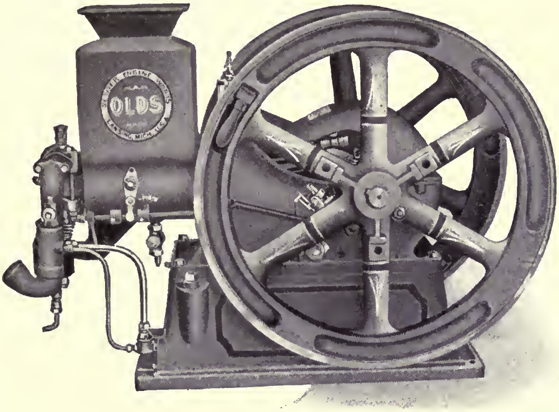


FIG. 23—AN ENGINE WITH THE HOPPER JACKET ATTACHED

The Trouble Calendar.

When the engine stops suddenly. Examine the wiring, look for breaks and loose terminals. See that the switch has not been accidentally opened, that the terminal nuts on battery, coil and spark plug, on contact maker and frame connections have been tightly drawn up. See that there is no verdigris on the terminal nuts, especially at the battery connections, that the wire has not been broken at any place, that the spark plug or contact maker has not become fouled, that the coil vibrator is working properly, that the gasoline cock has not been closed, that the water has not evaporated and allowed the piston to seize.

When the engine misfires and stops gradually. Test the battery. See that it is showing at least 4 volts if a voltmeter is available. See if the gasoline supply is sufficient. Examine the spark plug or make-and-break, and clean the points if necessary. Examine the platinum points of the contact maker or if of the wipe type, clean the face of the disc and spring. If a magneto ignition is used see if a spark is available and file the contact points smooth if required. If a jet carbureter is used see that the tube is clear and that the gasoline supply pipe is not choked or airbound, or that water has not found entrance to the carbureter and jet tube. Also see that no terminal nuts are loose or that unions on the gasoline supply are leaking.

When the engine is not developing enough power. Test the compression, if bad the piston rings should be examined, they may have turned in the cylinder so that the slots are opposite each other and the gas is passing. This is sometimes made evident by a smoky mark left on the outer end of the cylinder by the gases passing. An imperfectly bored cylinder will allow the rings to turn in this fashion. Examine the valves for pitting and regrind if badly pitted. Also examine the valve covers and spark plug. There may be a leak there. The electrical equipment may be the cause through a weak battery, the trembler on the coil may be vibrating too slowly and so making a weak spark, the coil contacts may be pitted or there may be too wide a space between the points of the plug. Or there may be too small a space when the spark will fail to ignite the gas. Set the points until a visiting card will just pass between them. The explosive mixture may be too rich or the gasoline may not be feeding properly. The fault may be mechanical. The valves may not be lifting high enough, the exhaust pipe or muffler may have become choked with soot, the inlet valve springs may be too weak or the engine may simply require lubrication.

When misfiring accompanies loss of power. Examine all terminals for defective connections caused by grease or rust, adjust the contact maker if necessary, test for a short circuit, see if the insulation is worn in any part and the bare wire is in contact with the engine. There may be water on the spark plug or in the coil case or water may have entered the carbureter or gasoline tank. The spark plug porcelain may have become cracked or the terminal may simply have become loose.

WHEN THE ENGINE OVERHEATS. The mixture may be too rich, or the exhaust valve may be throttling the exhaust by not lifting enough. The valves may be incorrectly timed or the exhaust pipe may be partly choked.

WHEN THE ENGINE KNOCKS. Examine the lubrication and the water supply to the jacket. The ignition may be too early or a carbon deposit in the valve chamber or combustion head may be causing self-ignition. Examine the piston head and cylinder for a deposit which might become red hot under compression and ignite the gases prematurely. Also examine all the bearings carefully. The cylinder may be loose at the junction with the crank case if the separate style of building is used.

WHEN THE ENGINE IS MAKING SOUNDS THAT SHOULD NOT BE MADE. If the spark plug is broken, the exhaust pipe split or the joint between the engine and exhaust pipe loose, a hissing sound will be apparent. If a squeak is emitted lubricate the valve stems and all of the bearings. If a "chattering" sound is apparent the bolts connecting the cylinder and crank case may be loose if the cylinder is bolted down to a separate casting. The bearings may be worn, loose, or simply out of adjustment.

WHEN THE ENGINE REFUSES TO START. It may be that the ignition is out of order. Test for a spark at the plug. Remove the high tension wire from the plug terminal and hold it close to the iron of the cylinder while the contact maker is operated. If no spark occurs follow the wires back to battery and if all wires and connections are sound test the battery. It may be due to poor compression. Try a richer mixture, give it as much gasoline as it will take and if the engine starts check down the gasoline supply until the emission of smoke ceases and the explosions are regular and strong. The inlet valve may be stuck to its seat. Press down the stem and inject some gasoline. There may be a leak allowing water to get into the cylinder. The leak may be at the connection of the cylinder and the head. If so fit a new washer or tighten the bolts down on the old one sufficiently.

When the Engine won't Stop when the Current is Switched off. There may be a deposit of carbon causing self-ignition or there may be an electrical short circuit through faulty insulation.

When Explosions Occur in the Muffler. Probably too weak a mixture is being used. Or the spark may be weak or intermittent. The cause is that a fresh charge of gas is passed into the muffler without ignition and is exploded by the flame of the next ignited charge.

When the Engine cannot be Cranked or the Flywheel Pulled Around. Faulty lubrication may have caused the piston to seize. Inject kerosene through the lubricator tapping or the spark plug socket. If the piston can then be moved lubricate thoroughly and look to the lubricator for a stoppage. If this is in good order look for a mechanical breakage.

When Explosions Occur in the Carbureter. The inlet valve is at fault, the valve is worn or the spring is weak. The valve or ignition timing may be wrong or the mixture too weak.

When the Crank Case Becomes Hot. Broken or worn piston rings are allowing the gases to leak by them. Look for signs of smoke on the crank case or cylinder walls.

Water Comes out of Cylinder and Engine won't Run Steadily. A leak in the cylinder. It may be at the junction with the head or in the walls of the cylinder itself. If the joint is in good condition look for a crack or blowhole, especially if the engine has been overheated or the water in the jacket frozen.

Repair Hints.

Trouble in starting gasoline engines in most cases arises from minor faults in ignition and by carrying out a systematic test these can be located easily. If no explosion follows on turning the piston over the compression and with the carbureter and valves presumably in good working condition, remove the spark plug, first switching off the current.

Then connect the wire to the plug again and lay it on a convenient part of the engine so that the metal body of the spark plug is in good metallic contact with the metal of the engine. Switch on the current and turn the wheel over until the contact is made at the make and break. The trembler should then "buzz" if the batteries and wiring are in good condition. If there is no "buzz," first make sure that the contact breaker is acting so that the spring is in good contact with the metal segment of the disc or that the two platinum points are in close contact.

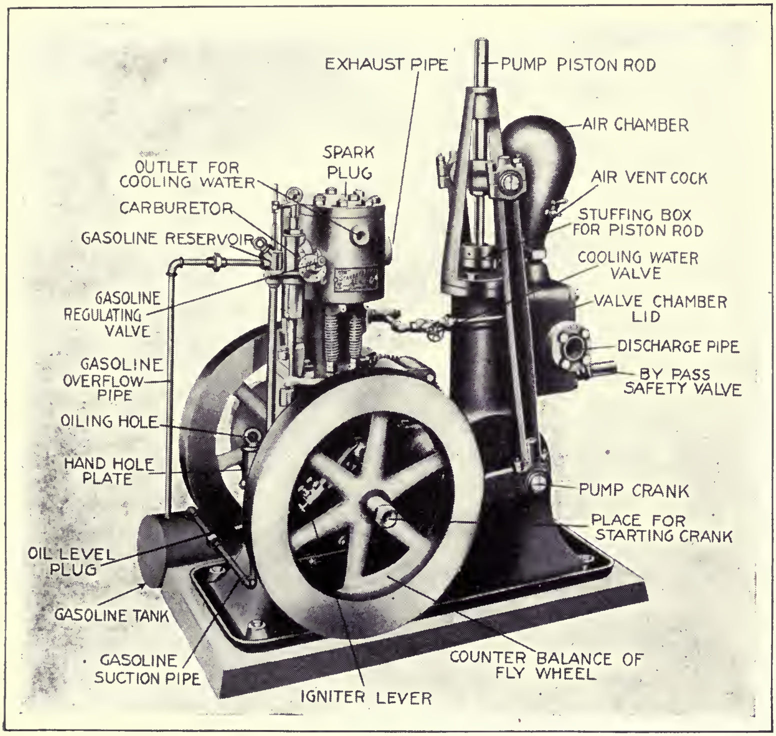


FIG. 24—VERTICAL ENGINE WITH COOLING WATER SUPPLIED BY BY-PASS FROM PUMP

When assured that this is acting properly and if no "buzz" is apparent at the coil, turn the adjusting screw of the vibrator so as to loosen it. Then tighten it until it passes the point at which it was originally set. If this starts the trembler, take out the adjusting screw and trim up the platinum points. Then replace the screw and adjust it so as to secure a high singing "buzz" with the hottest spark available. If the vibrator is working all right but no spark occurs the plug is cracked or short circuited, or the wire is broken under the insulation.

If adjusting the trembler screw has no effect and it cannot be made to vibrate, examine the battery and the terminal connections. Try an ammeter or a voltmeter on the battery. The voltmeter should show about 4 volts at least. If less than 3.5 it is too weak to cause a hot spark at the plug under compression although it may operate the coil trembler and cause a spark of a weak nature to pass the plug points. The ammeter will show an amount of current passing according to the size and number of the cells. The capacity is marked on each as a rule. An ammeter should not be used on an accumulator in any circumstances. The discharge will be too rapid and it will ruin the plates. Use a voltmeter on an accumulator.

If the ignition is of the make-and-break type remove the igniter plug and trim the platinum points so that they will come evenly together. They should be finished perfectly smooth with a fine file or fine emery on a cloth wrapped round a file. If the igniter can be manipulated without putting it back into position test out the current in that manner. If not apply the voltmeter to the cells and if the current is sufficient put back the igniter and connect it up. If no spark occurs try each wire by touching the two terminals of the battery with the ends or by the voltmeter. If the wire is broken no spark will result or current show on the voltmeter. If whole a slight snap and spark will show that it is so, when the terminals should be examined to see that good contact is made and no rust or grease is interfering with the proper electrical contact of wire and metal.

See that no frayed part of the wire is the cause of a short circuit by coming in contact with the metal parts of the engine or that the insulation is not burned by too close contact with the hot exhaust pipe. The insulation should be carefully examined throughout the entire length of the wire to make sure that there is no grounding at any point.

CHAPTER IV.

SETTING GASOLINE ENGINES AND PUMPS

In setting any of the engines illustrated the necessity of providing a sound foundation should be borne in mind. Constant vibration will loosen the bolts and probably throw some part out of alignment if this matter is not carefully attended to. The foundation should be of concrete for preference but heavy timbers so placed as to take the vibration of the engine lengthwise may be used with satisfaction. If an engine with a pump driven by gearing mounted on a separate base is used, both should in all cases be mounted on the same timber. If placed on separate blocks there will be a possibility of a movement occurring when the engine is running that may lead to binding of the gears with consequent excessive friction and probable damage to the teeth.

It is important that the engine and the gearing should be set in perfect alignment and this should be strictly attended to when the foundation bolts are placed in the concrete or the holes are drilled in the timbers for the bolts. As a rule it will be found most convenient to place the bolts in the concrete when the base is being put in and in such cases a long bolt with a head of sufficient size to ensure a sound hold in the concrete should be used. When a bolt is passed through a wooden beam placed as a foundation large washers should be used behind the head to prevent it working into the wood and so gradually becoming loose. If the engine is placed in a small wooden building, as is very often done, a proper support for the wooden engine foundation should be provided as the floor joists are not as a rule nearly heavy enough to provide a satisfactory support. Probably it will be easy enough in most cases to build a brick or stone pier under the floor which will ensure a substantial and vibrationless base upon which to set the timbers and then the ingenuity of the fitter may be exercised in arranging the ties of the base so that it will remain steady under the load and vibration of the engine when working.

Types of Engines and Pumps.

Two types of engines with vertical pumps mounted in such a manner as to conserve space to the maximum are shown in the illustrations in Figs. 24 and 25. The first of these shows an engine set upon the same cast-iron base as the pump which it drives through a crank motion suitably geared from the engine shaft. This makes a compact and smooth working outfit which is suitable for pumping to either an open tank or to a pneumatic tank as desired.

The second illustration shows a smaller engine mounted on a pump which may be disconnected and driven by a windmill if desired. The engine in this case is readily detachable and may be moved around to do a variety of work with great ease. A suitable base and gearing is provided so that the connection to the pump pitman rod will be rigid and there will be a freedom from vibration when the engine is running. The gasoline tank is attached to the engine outfit as is also the battery and coil for the electrical ignition. The water jacket is made in the form of a hopper and is of sufficient size to admit of the engine running a reasonably long time without attention. In any case it is a simple matter to provide a small water connection and petcock so that a small stream of water may be allowed to run into the hopper while the engine is running. The engine shown in Fig. 26 is of a somewhat different type. It is a horizontal engine and is driving a horizontal single cylinder double action pump but is so mounted that the base is short and the space occupied comparatively small. This is secured by mounting the engine on a cast-iron frame at a sufficient height to permit of the gearing and transmission to the pump being placed below the engine. Then the pump may be placed on a line with the end of the engine cylinder, saving the length of the crank and connecting rod. The engine as shown is

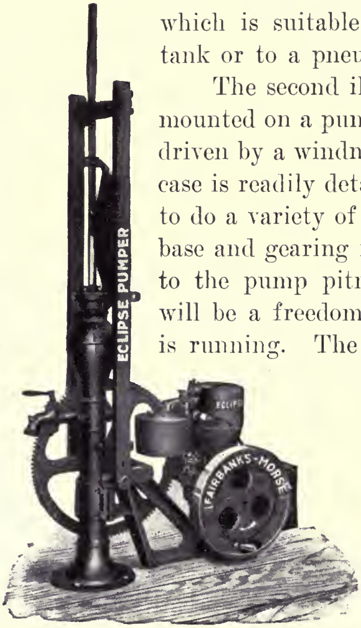


FIG. 25—SMALL ENGINE ATTACHED TO WINDMILL PUMP

fitted with a hopper jacket but may have a circulating tank and pipes if preferred.

A horizontal engine connected with a deep well pump is seen in Fig. 27. In this instance the pump is placed some distance down in a well of the open type and a working head is used to transmit power to the pump rod. There is practically no difference in the pump used from the ordinary single cylinder force pump shown on the engine and pump outfit illustrated in Fig. 25 but by placing it in this position it may be set at any distance from the water line within the pumping limit, namely about 25 ft. The connecting rod from the working head to the pump rod may be of iron pipe, wood, or bar iron as circumstances demand.

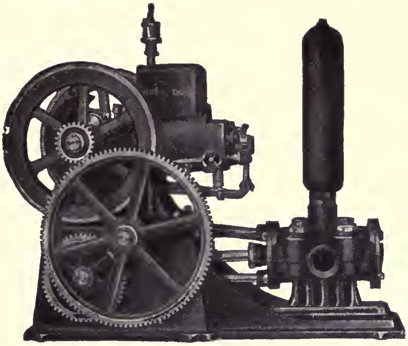


FIG. 26—ENGINE MOUNTED OVER PUMP TO SAVE FLOOR SPACE

The engine used is of the horizontal type with a hopper jacket although of course a vertical engine could as well be used. The pump shown has a short lift and is of comparatively large diameter. The amount of lift is adjusted on the gears by setting the crank pin at the same distance from the center of the shaft that it is desired to lift the pump piston. A flange on the pump secures it firmly to the support on the well and this of course is variable to any height.

A compact arrangement of engine and pump with an air pump attachment designed for use with a pneumatic tank is shown in Fig. 28. The gears in this case while accessible are in such a position as to be little likely to cause accidents and detachable guards add still more to the safety of the persons who approach the engine while running.

These examples are probably the most commonly used types of gasoline engines with direct geared transmission to pumps. Any of the pumps illustrated might have been driven by a belt with satisfactory results although with more waste of floor space. The matter of transmission however is one that must be decided according to the conditions under which the pump is to work.

Rotary and Centrifugal Pumps.

There are four types of pumps in general use for raising water, namely the jet, rotary, centrifugal and reciprocating types. The first is not used to any extent as a means of raising water for storage as a water supply but is largely used in other lines. It will be recognized as an appliance in everyday use in its form as an injector or ejector forcing water into steam boilers at comparatively high pressures and raising water from various pits and tanks and delivering it to levels of moderate height.

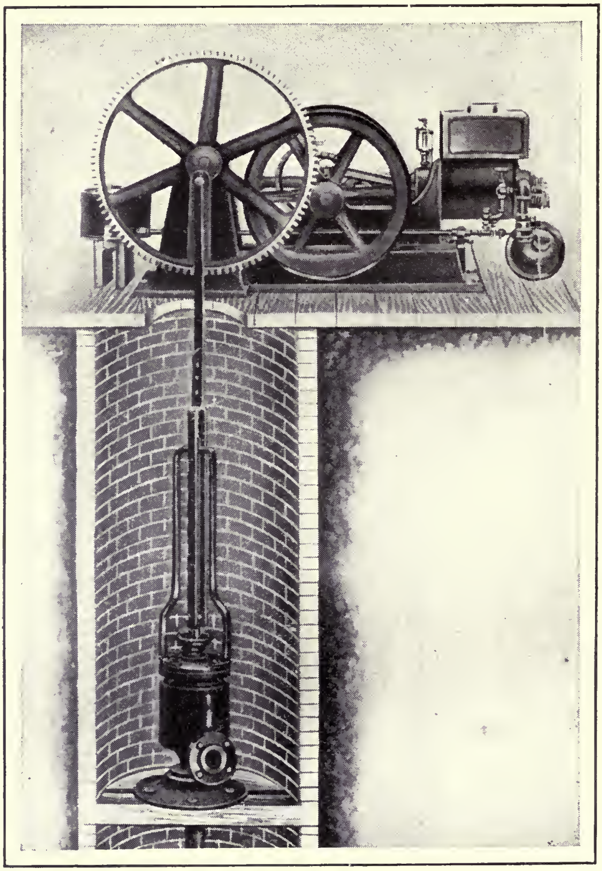


FIG. 27—HORIZONTAL ENGINE OPERATING DEEP WELL PUMP

Such a type of pump is not suitable for use in water supply work principally because of its low efficiency. Although as an injector or ejector it is in most instances highly efficient it would be the reverse of economical as a pump for water supply and therefore it is little used as such. Rotary pumps are commonly used and are easily adapted to be driven from any source of power. They are equally well adapted to be driven by electrical power, gasoline or steam engines and their compactness and ease of attachment make them popular for use where the lift is comparatively low. There are many different makes available but the principle in all is the same.

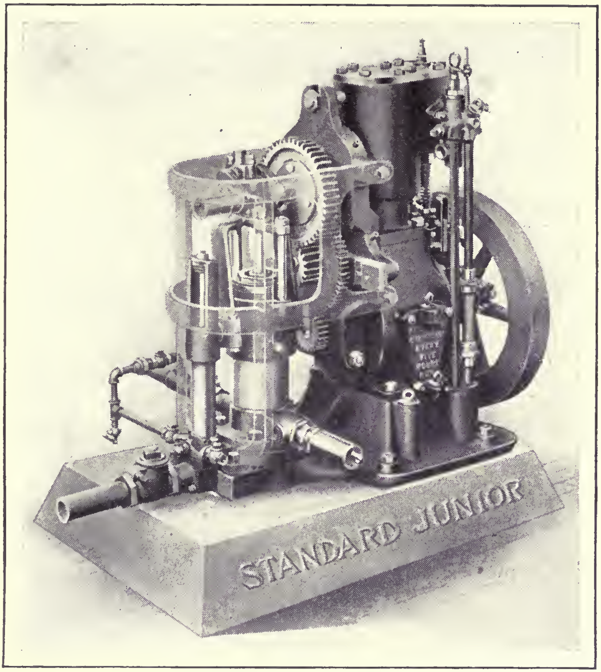


FIG. 28—COMPACT ENGINE WITH AIR PUMP FOR PNEUMATIC SUPPLY AND WITH GEARS PROTECTED

The water is raised by the revolution of two propellers in a closely fitting case, being swept around from suction pipe to delivery pipe by the lobes of the propellers and prevented from falling back by the same means. The design of the propellers marks the principal variation in the pumps of various manufacturers.

A very common style is that where two pinions in mesh are caused to revolve, the teeth or lobes of each being almost a close fit to the casing in which they revolve. The revolution of the two pinions into each other carries a constant stream of water to the upper part of the casing and the friction of the water against the sides and the partial vacuum formed at the lower part of the casing in consequence of the upward movement is sufficient to promote a steady flow through the outlet. A check valve is always fitted on the suction pipe to prevent the water falling back when the pump is stopped and a ready means of priming the pump is generally provided. A variation in the design of the lobes is seen in Fig. 29, where the pinions are replaced with pieces of tube fastened on propellers of a peculiar section. These tubes are fastened on opposite sides of the propeller and it may be noticed that they project beyond the surface for a distance of about half their diameter. They are caused to engage with semi-circular depressions in the opposite propeller as it revolves and thus act in the same way as the teeth on a regular pinion. The lobes of course carry the water around so long as they continue in motion and the cohesion prevents its turn to the lower side of the casing as previously noted. The ouside appearance of a rotary pump is seen in Fig. 30. The priming cap is seen on top of the casing in the illustration and the compact appearance of the pump is noticeable.

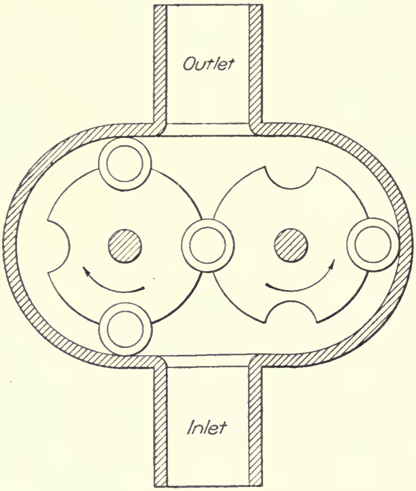


FIG. 29—DETAILS OF ROTARY PUMP

Centrifugal Pumps.

Centrifugal pumps have many features in common with the rotary type. They are compact and easily attached, throw a continuous stream and are free from vibration and water hammer. In their simple form they are not very efficient excepting at comparatively low heads, about 35 to 40 ft. being the limit at which they show fair efficiency. As however the reciprocating pump shows the lowest efficiency at low lifts this is clearly the condition which favors the installation of the centrifugal pump or the rotary pump for that matter.

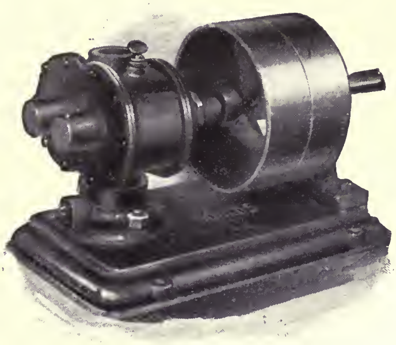


FIG. 30—A ROTARY PUMP

It is also possible with the modern and elaborate forms of centrifugal pump to raise water with certainty and economy to an elevation of several hundred feet. These improved pumps are generally known as multi-stage turbine pumps and as the name would imply, the design of the pump causes what may be termed a compounding of the lifting power of the impellers in the different sections of the pump, causing it to raise the water correspondingly higher. The principle of centrifugal force is seen every day in the workshop, in the street, in the garden. It is the force which throws the water off a grindstone, the mud from a carriage wheel and which makes the lawn sprinkler sprinkle.

When a wheel or impeller with suitably shaped spokes or blades, such as are shown in Fig. 31, is revolved in a casing filled with water the water is thrown to the outside of the wheel and a suction is created at the center. The whirling motion given to the water sends it out through the outlet pipe and water is drawn in to replace it and to fill the vacuum created at the lower part of the casing through the inlet pipe. The shape of the casing is also made to assist in the suction and forcing out of the water, being constructed to give a gradually increasing velocity from the entrance of the suction pipe to the impeller and a decreasing velocity in the discharge pipe from the impeller to its outlet. The shape of the casing and pipes is also designed to prevent eddies and loss of efficiency by friction. The impeller in some cases has its sides covered by discs and is then known as the enclosed impeller type

Screw Pumps.

A highly efficient type of pump which has much in common with the rotary type is known as a screw pump. This is used to a considerable extent in raising water in city buildings but not so much in country water supply although it is quite as well suited for that purpose. The screw pump operates through two shafts upon which worm threads are turned. One of these is a left hand thread and the other a right hand and one of each is turned on each shaft. These shafts are geared so that they engage with each other and the water entering the casing at each end of the screws is drawn toward the center by the revolution of the shafts.

The screws fit the casing closely and as the course of the water is toward the center and the shafts engage with right and left threads pitching both ways there is no end thrust on the bearings. The pump may be driven direct from a gasoline engine or an electric motor or it may be driven by a belt or gearing as circumstances or convenience may dictate.

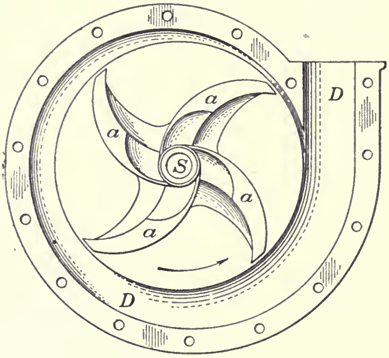


FIG. 31—DETAILS OF CENTRIFUGAL PUMP
S—Inlet *a*—Impellers *D*—Discharge

Duplex and Triplex Pumps.

A reciprocating pump of the triplex or three-cylinder type is shown in Fig. 32. These are gear and belt driven as may be desired. Either is suitable for pumping to elevated open tanks or to pneumatic pressure tanks as desired. A countershaft hung on wall or ceiling brackets is a convenient means of transmitting power when it is desired to place the motor in a different position. This is the method commonly used where a large pneumatic system requiring a separate air compressor is installed.

A single acting vertical pump driven by a motor mounted on the same base is shown in Fig. 33. On this pump the gears used to transmit the power to the pump from the motor are covered and the motor is mounted in such a position as to be unlikely to be affected by water should there be any leakage from the pump or its connections.

Another method of mounting the motor is shown in Fig. 34 which represents a horizontal pump driven through a worm gear, crank, and connecting rod. The design of the pump is very compact and both it and the motor are placed on a common base.

The only other type of reciprocating pump in general use is the double acting pump with a single cylinder. This type is generally made in a horizontal pattern and as it has two sets of valves and water is alternately raised and forced by each end of the piston it is a powerful and smooth acting type of pump. The valves on this type of pump and also on the triplex style are of the disc type and may be made of brass or of hard rubber.

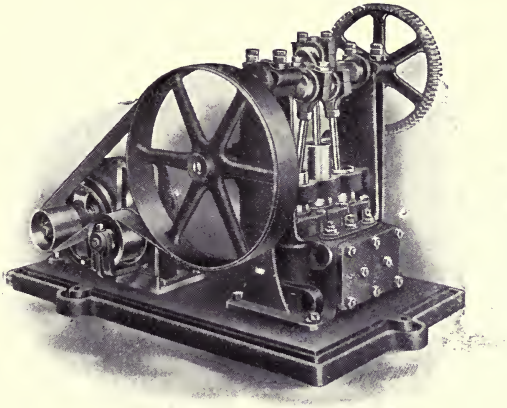


FIG. 32—TRIPLEX PUMP BELT DRIVEN FROM MOTOR MOUNTED ON SAME BASE PLATE

Locating Pump Troubles.

The principal troubles met with in connection with pumps for domestic water supply are leakage, insufficient supply, loss of priming, breakage of parts, and freezing. When leakage occurs it is almost certain to be the result of a packing wearing out or the stuffing of a gland becoming frayed and worn by friction. In either case the remedy is obvious and the only care necessary is that the parts shall be taken apart and re-assembled properly.

The pump should be looked over carefully before any part is taken out so that unnecessary labor and trouble will be avoided. When a stuffing box or gland is to be re-packed the asbestos or wicking should be twisted properly before inserting it in the box. If washers are used care should be taken not to destroy them by careless fitting and if they are a tight fit on the stem that the nut be not too firmly screwed home until the pump has run a few strokes. If this is not attended to a bent piston rod may be the result.

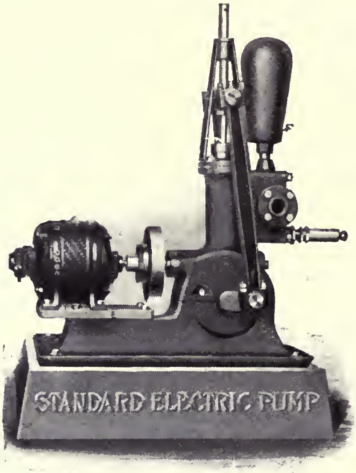


FIG. 33—VERTICAL PUMP ELECTRICALLY DRIVEN BY MOTOR MOUNTED ON COMMON BASE

An insufficient supply of water from a pump may be due to several causes. The motive power may be insufficient and the pump be running too slowly. The piston packings may leak or air may be entering the pump at some point. The judgment of the fitter must be used to determine which is the cause of the trouble but if a tee or other fitting near the pump is available the action with this open may be a guide to the possible cause as the action under a light load may then be noted.

Loss of priming is due either to a leaky valve at the pump or a leak in the suction pipe. If an air vessel is used on the suction side of the pump this should have attention in restarting so that it will be quite empty and consequently fit for proper service.

If an air vessel is used on the suction pipe as well as on the discharge a pet cock should be fitted to it so that air may be drawn in when the suction pipe is allowed to empty, or for recharging while the pump is being run. An air chamber relieves the pump considerably when the suction is heavy and lessens the probability of water hammer occuring in the system.

Spring relief valves are occasionally used for the same purpose and these are intended to open and relieve excess pressure gained as the result of a sudden stoppage of the flow. The closing of a hydrant or a ballcock may operate to cause a recoil in the pipe and if a relief valve is fitted a small quantity of water will be discharged there and the recoil will not be accompanied by hammer. Relief valves are also used in systems where the pump is attached direct to the supply system without a storage tank, as in greenhouse sprinkling systems. If they are not kept in proper repair excessive pressure may be generated by the closing of valves on the sprinkling lines and the result is likely to be a stoppage of the engine and possible damage to it and the pump.

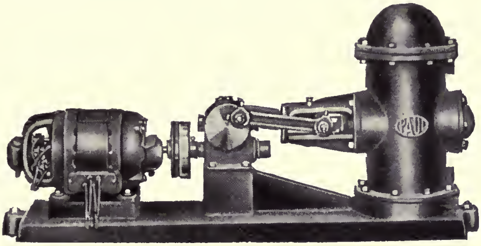


FIG. 34—A COMPACT HORIZONTAL PUMP DRIVEN BY WORM GEAR FROM MOTOR

The sound of water hammer is distinct from that made by a loose part or a worn bearing and is easily recognized by the experienced mechanic. If the sound is proceeding from the pump however it will be well to examine the piston and crank bearings which may require re-bushing.

Check or foot valves should be examined carefully when a pump is losing priming and grit should be removed from these and from all packings or gaskets before the parts are re-assembled. A very small air leakage on a suction pipe is sufficient to prevent the proper working of a pump and a much reduced discharge will be made from pumps of the duplex or triplex types if one of the valves should leak slightly.

When pumps are dismantled in cold weather great care should be taken to get all of the water out of them. If hollow plungers are employed these should be removed entirely and water or oil contained in them removed. All plugs should be removed and pet cocks left open so that condensation forming will not collect and freeze.

CHAPTER V.

HOT AIR ENGINES, WINDMILLS AND ELECTRIC MOTORS

Perhaps the simplest type of engine in practical use is the one which is operated by hot air. Converting heat into work in a manner similar to a gasoline engine, that is by setting its working parts in motion by the expansion of a gas, it yet differs entirely from the internal combustion type. The latter's source of power is in the expansion of the products of combustion of the fuel while in the former the heat of combustion is not directly utilized but is transferred by radiation and conduction from the fuel to the air confined in a working cylinder. The resulting expansion of the air is the force that moves the piston, the tangible evidence of the conversion of heat into work. Thus the hot-air engine is more nearly allied to the steam engine than to the gas engine, the chief difference being in the medium of expansion and the absence of any exhaust.

Hot-air engines are not used to any extent outside of the purposes of water supply by pumps. Besides steam or gasoline engines, they show a low efficiency and they only have their simplicity and ease of operation to recommend them for that purpose. These factors, however, are of so much importance that the low efficiency can in many cases be overlooked, the fuel cost being negligible in an engine of such low power and easily made up for by the lesser cost of attention.

The engines are made in several different styles: the furnaces are made to burn wood, coal, oil, or gas and the compression and expansion of the air may be accomplished either with the use of two separate cylinders or of one in which moves two pistons. The latter is the most commonly used as it is more cheaply constructed though not so efficient as the double pattern. The single-cylinder engine shown in Fig. 35 is fitted for burning gas but when coal or wood is the fuel a furnace pot is fitted as shown in Fig. 36. The action of the engine is as follows:

When fire has been maintained long enough in the furnace to heat the lower end of the cylinder to almost a red heat, the flywheel is turned over once or twice to start the engine. As shown in the illustration the air piston is nearly at the end of its compression stroke and the transfer piston has completed about a third of its upstroke. This transfer piston does not fit tight in the cylinder and as it compresses the air between it and the air piston the air is forced downward to the space at the lower end. As it passes over the hot surface it quickly becomes heated, expands, and immediately forces the air piston upward. As the air piston is forced upward the transfer piston moves down and the hot air passing over the cold surface of the cylinder where it is water-jacketed contracts to its normal volume, thus allowing the air piston to return again. On the return stroke the air is compressed and forced down to the heated part of the cylinder again. The cycle is repeated as long as fire is maintained in the fire box.

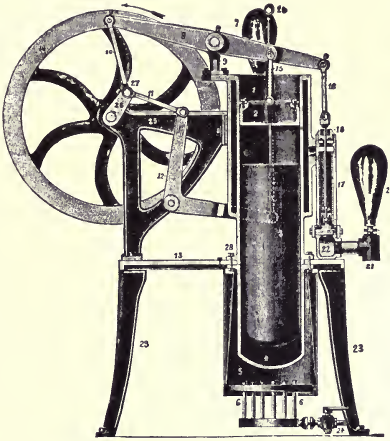


FIG. 35—HOT AIR ENGINE OPERATED BY GAS

As the alternate expansion and contraction of the confined air is the source of power no exhaust is necessary, the same air being used indefinitely. An impulse is given every revolution so that the momentum of the flywheel is sufficient to bring the pistons back to the relative positions to cause the next impulse. It will be seen that the number of working parts is small and the action simple.

The other type of hot-air engine, using separate cylinders for compression and expansion, is designed for heavier work and is better suited for deep well pumping or for raising water to any considerable elevation. This type is shown in Figs. 37 and 38. The action of the engine is similar to that of the single-cylinder type. The compression piston C in Fig. 38 descends and forces the air contained in the lower part of the cylinder up the annular space between the piston and the cooling jacket, through the passage way or regenerator H H to the power cylinder B. The compression effected is about two-thirds, that is, the air is compressed to about one-third of its volume at atmospheric pressure and on entering the heating cylinder on the completion of the compression piston stroke it is instantly expanded, with an increase of pressure proportional to the temperature.

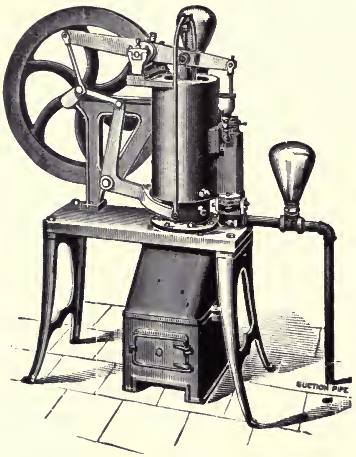


FIG. 36—HOT AIR ENGINE FITTED FOR COAL OR WOOD FUEL

This forces the power piston upward and as it reaches the upper half of its stroke it is assisted by the re-action of the pressure on the compression piston C.

The power piston on its return stroke drives the air back through the regenerator where a series of thin iron plates absorb a large proportion of the heat it contains. By the time the compression piston has reached the end of its upstroke the power piston has driven most of the air back and its contact with the cylinder walls, surrounded by a water jacket has caused it to contract to its normal value again. The compression piston descends and repeats the operation just described.

As the hot air passes through the regenerator back to the compression chamber it loses heat to the baffle plates set there for that purpose and on the return of the air after its cooling and compression on the next cycle, it picks up part of the heat again, thus heat is economized to a considerable extent. An air inlet valve is fitted at L for the purpose of admitting air to the compression chamber should its contents at any time fall below atmospheric pressure through leakage at the piston packings.

It will be noticed that leather piston packings are used. These are double and are kept from overheating and hardening by a water jacket T. The lower parts of the pistons which are subjected to a considerable heat are filled with non-combustible and nonconducting material and the flow from the pump is caused to pass through the main water jacket to keep it constantly cool. The small jacket on the expansion cylinder head is connected by a small tube with a regulating valve as shown in Fig. 38, and a small stream is allowed to pass through it and go to waste.

The pumps used on the single-cylinder engines are generally single acting pumps of simple construction, fitted with an air chamber on both suction and delivery ends. Deep well pumps may be attached to the larger sizes of single-cylinder engines if it is possible and convenient to place the engine over the well. This provision of course also applies to two-cylinder engines when such a pump is required as the drive is direct in both cases.

Double-acting pumps of the vertical type may also be used on occasion, in fact the pumps usually fitted to two-cylinder engines are of that type with special flat valves. The suction valves on the small single-acting pumps are often merely cylindrical pieces of rubber which revolve and offer an ever changing surface to the wear. They are placed in a chamber at the bottom of the cylinder and lie over a port or slot with a smoothly turned face so that the rubber is in close contact with the metal.

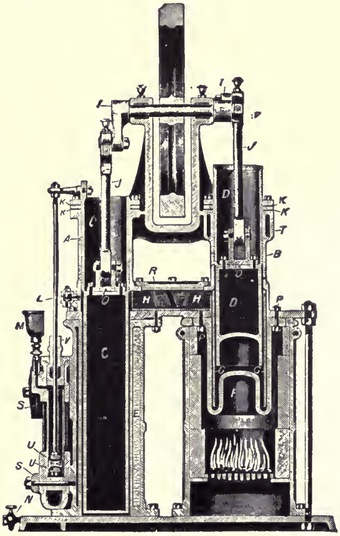


FIG. 37—TYPE OF HOT AIR ENGINE USING SEPARATE COMPRESSION AND EXPANSION CYLINDERS

Maintenance and Repair of Hot-Air Engines.

One common cause of trouble in a hot-air engine is the too liberal use of lubricating oil. If this is poured into the cylinder with a mistaken idea that it will keep the compression good and the leather packing flexible it will in a short time burn out and leave a charred deposit which will cut the leather and score the walls of the cylinder. All that is required to keep the engine in perfect running condition is a slight film of oil on the walls and the oil should simply be applied with a rag often enough to keep the leather moist.

The cup packings on the transfer piston rod and pump piston rod when worn out, should be replaced with packings of the same pattern. Asbestos packing or cotton wicking packs too closely and offers too much friction for this type of engine. A little graphite applied to the piston rod now and again will help to reduce the friction and will not have any injurious effect on the leather.

When the engine is stopped and a fire is maintained in the firebox the flywheel should be turned over until the transfer piston is at the top of its stroke and a piece of wood should be inserted between the spokes to hold it there. This will effectually guard against burning out the piston or overheating the parts which might occur if left at its lowest position exposed to a high temperature. It is well also to cover the engine with a canvas cloth when it is not in use so that dust and moisture will not find its way into the cylinder.

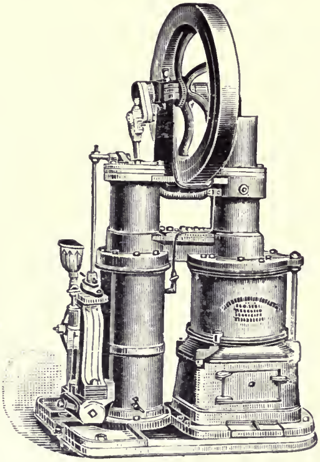


FIG. 38—DOUBLE CYLINDER HOT AIR ENGINE WITH WOOD OR COAL FIRE BOX

The wearing out of the main piston packings may be known by the scorched appearance of parts of the cylinder, or hissing sounds which can be traced to escape of air around the piston and which will show air bubbles if a little oil is introduced around the outer ring of the piston when it is at its highest position. Then it is necessary to fit a new leather packing. This should be done with care and it is generally more satisfactory to procure a packing which has been cut to a standard size and thickness at the factory of the engine maker rather than attempt to make one by hand. If the leather is too thick it will be hard to turn the leather over so that it will fit the cylinder without wrinkling and allowing air to pass. The same applies to plunger packings and foot valves when the flat type is used. If these are too thin and soft, poor results will be obtained and if too thick and stiff they will be equally unsatisfactory.

Windmills.

The windmill as a source of power for raising water has many features to recommend it. The machinery is of the most simple construction and therefore may be handled readily by anyone with the most elementary knowledge of mechanics. It is little likely to become inoperative with ordinary usage and only an extraordinary storm is likely to damage it if it is erected in anything like a substantial manner. The only attention required to the mechanical parts is a periodic lubrication and the pumps connected with it are simple for the reason that it is not generally put to any very severe service.

The conditions under which the best service is rendered are where the wheel can be placed in a favorable position to catch the prevailing wind of course. If in addition the lift is not excessive, satisfactory operation is assured. Should a heavy lift be necessary a wheel of large diameter is necessary and in addition the gearing must be such that the number of strokes made by the pump is proportionately low. This is a matter which local conditions must control and the maker of the mill is generally ready to advise as to the selection of the best size and combination of pump when the work that the mill is to do is outlined.

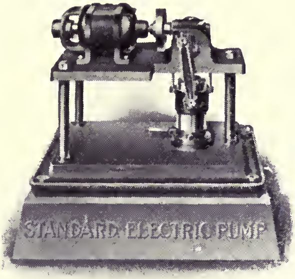


FIG. 39—ELECTRIC MOTOR DRIVING DEEP WELL PUMP

The American windmill of standard design consists primarily of a steel plate wheel ranging from 8 ft. to 12 ft. in diameter. The wheel is built up of vanes mounted on a light iron framework and is provided with gearing transmitting motion to a pitman rod through a clutch which is thrown in or out by means of a lever conveniently placed at the foot of the tower which supports the wheel and operating mechanism.

A brake is also provided to stop the wheel when thrown out of gear and a vane automatically keeps the wheel to the wind when in action. The wheel shaft runs in a long bearing supported on a cast-iron standard and this bearing is as a rule lined with babbitt. The large gear wheel engaging with the spur attached to the end of the shaft is also fitted as a rule with three bearings into which the wrist pin of the crank operating the pump rod may be fitted at option. This provision is made so as to offer a choice of lift of the pump rod to suit varying conditions of service and is equivalent to a change of gearing as the pump may be made to throw more or less water at each stroke by the variation in the stroke given it. Lubricating cups are fitted to the bearings and as the lubricant generally recommended is a heavy oil or grease, the attention to this detail required may be minimized. Probably once or twice in a year of service will be found sufficient for refilling the cups while the bearings may not require renewal for many years.

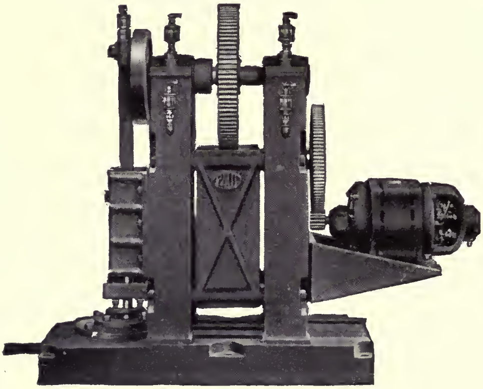


FIG. 40—CONVENIENT METHOD OF MOUNTING MOTOR

The tower upon which the wheel is supported may be built of angle iron with light bar braces or it may be of the tubular type. The latter is adopted frequently when the tower is more than usually high, and when a wheel of large diameter is used, as it lends itself to rigidity without undue weight of metal. It is also better adapted to the support of heavy weights as when a tank of large size is placed at the top of the tower and the mill mounted over it. This arrangement is very common in the larger sizes and tanks of 2000 to 5000 gallons capacity constructed of cypress in the accepted design for outside water tanks are commonly mounted in this fashion.

Towers vary in height from 30 ft. to 60 ft. or more, as the service demands, and the weight and number of the braces and manner of construction vary accordingly. It is necessary in erecting a tower of any size that it should be set perfectly and the foundation for the main supports therefore must be laid with care. Concrete forms the most acceptable foundation and is the most easily prepared. It will generally be found best to make forms for the main members of the tower and the position of these must first be located. Then the forms, which may be of wood or metal should be placed and the tie bolts which serve to hold the main members in position should be inserted so that they will project the correct distance above the finished surface of the concrete post which the form will produce, and very carefully levelled and measured to ensure that the tower will be in correct alignment with the center when completed. The nature of the soil will determine the depth to which the concrete base posts must be carried, and the weight of the tower and mill the width and length of the form. Once the first part is set the erection of the rest of the tower is a comparatively simple matter as the various members are invariably supplied so that the parts go easily together.

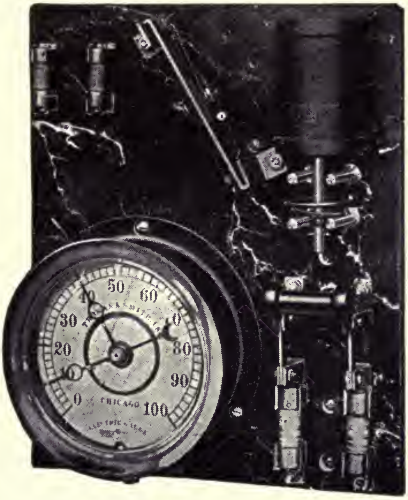


FIG. 41—CONTROL BOARD FOR ELECTRIC WATER PUMP

The chief drawback of the wind mill method of pumping is the uncertainty of operation. This is entirely at the mercy of the elements and the only means of safeguarding the supply is to provide a storage tank large enough to carry the demand over a reasonable length of time. Here again local conditions must determine what that shall be. It has been said that the pumps used in windmill work are of a simple description. They generally consist of a single-cylinder single-acting pump with a barrel from 2½ in. to 4 in. in diameter. The barrel is as a rule lined with brass and the valves are of the poppet pattern. The pump rod is connected to the pitman rod from the mill in a sleeve which admits of its ready disconnection for repair.

Pumps of the syphon type, when the supply comes from a point allowing it to flow to the pump by gravity, are also commonly used as also are anti-freezing pumps in which the working parts are placed in an open well at some depth below the surface and operated through a working head. Again, the well may be of the artesian type when the operation is also through a working head. This is simply a cast-iron frame work with guide rods which serves to connect the pitman rod from the mill to an extension from the pump rod of a pump, the chamber of which is placed in a tube sunk into the ground the distance required to reach the water table. The windmill may be also controlled through the action of the pump and automatic appliances are available which throw the wheel out of gear as soon as the water in the tank reaches a predetermined height.

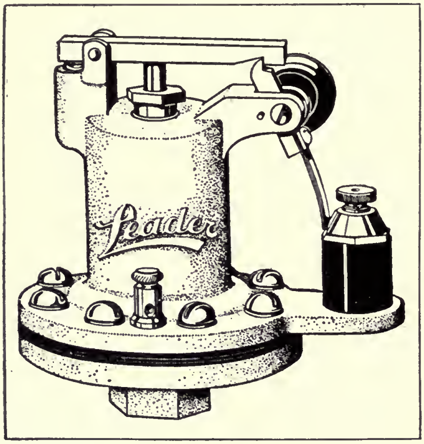


FIG. 42—DIAPHRAGM OPERATED ELECTRIC SWITCH

Electric Motors and Control.

Where electricity is available it forms an ideal source of power for the operation of water supply pumps. Besides the smooth and silent operation of the motors the ease of control which is obtained is a feature which alone is of the utmost value. Motors may be driven by direct or alternating current and all that is necessary in installing them is to see that a firm base is provided and that correct alignment with the pumps is made. In many cases even this care is unnecessary as pumps with motors mounted on the same base are in common use.

The method of adapting these motors to pumps of various kinds is illustrated in Figs. 39 and 40, where in Fig. 39 a motor is shown driving a working head over a deep well pump through a worm-geared shaft. A convenient method of mounting an electric motor which can be used when the power is changed over from a gasoline or other engine to electricity is shown in Fig. 40.

In Figs. 41 and 42 pressure control appliances are illustrated. These are designed to throw a switch and start or stop the electric motor attached to the pumping machinery at such times as the pressure falls below or rises above that at which it is desired to maintain it in a pneumatic system, or when the water level in an overhead tank rises or falls beyond the desired point. The location of these appliances in a pneumatic water supply system is shown in Fig. 43 where a motor driven compressor is shown with its connections to an air storage tank in connection with a water

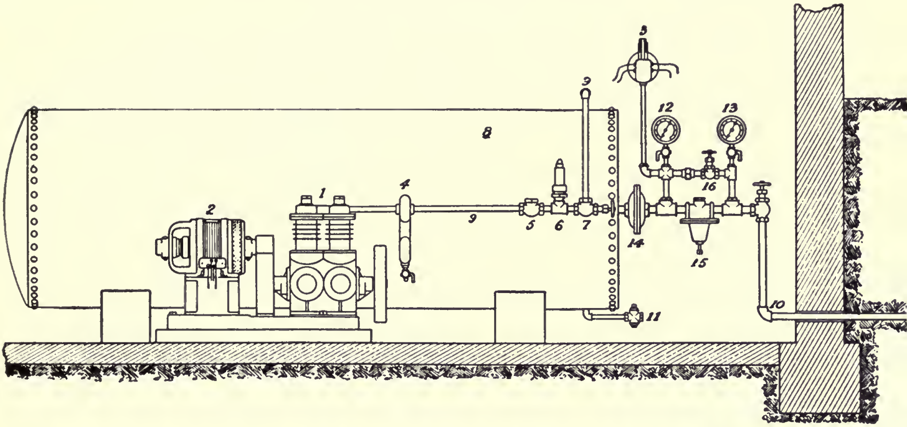


FIG. 43—DETAILS OF CONTROL CONNECTIONS TO MOTOR ON PRESSURE SUPPLY SYSTEM

raising plant. The pressure actuated control of the motor is indicated by the Fig. 3 in the diagram. Another type of control, when an overhead tank is used, is that where a float in the tank operates a switch. In either case the control of the motor is positive and the operation can be made entirely automatic, which is hardly possible with any other form of power.

CHAPTER VI.

STEAM DRIVEN PUMPS

The reciprocating pump which is operated direct by a steam driven piston is a type which is commonly found in use for boiler feeding, drainage, water supply, and in fact every conceivable use to which a pump can be put. The type used for the purpose for which plumbers are called upon to handle them is generally a single-cylinder double-acting plunger pump. One of these is shown in the illustration in Fig. 44. This is the simplest type of steam pump and one that is very free from trouble. The outside packed plunger makes for simplicity. A leakage is readily noticed and repaired and grit which may enter with the water is not liable to damage the cylinder or valves.

For larger supplies or heavy lifts a duplex or two-cylinder pump is generally used. This gives a more constant flow of water and is also better in this respect, that there is less water hammer where the head pumped against is heavy.

The alternative style of the same type of pumps is that in which a packed piston is used instead of a plunger. This pump is shown in Fig. 45. These illustrations also clearly show the steam cylinder and piston, steam valves controlling admission and exhaust, the connecting rods and rocker arms which operate them and the water cylinder and piston with delivery and inlet valves in a chamber over the cylinder.

A duplex or two-cylinder pump is shown in Fig. 46. The duplex pump is in fact two single pumps set side by side, the slide valve S which controls the admission and exhaust on each receiving its motion through the rocker arm and its connection with the other piston. The illustration shows the right hand piston P carrying a piston rod R, passing through a stuffing box and having a spool M attached about its center with clearance between the shoulders to admit the lever L.

As the pressure of the steam moves the piston out, this spool, which is engaged with the lever L, causes the lever to turn the shaft

B. On this shaft is fastened another crank which is attached to the valve rod of the left-hand piston through a link and thus the ports are alternately covered or uncovered in the left-hand cylinder through the motion of the piston in the right-hand one, and vice versa as the right-hand valve is operated in the same manner from the left-hand cylinder. It will be noticed that there are two ports on each side of the steam piston. These are used to gain a steam cushion by reason of the piston closing the exhaust port before reaching the end of its stroke and also so that live steam can enter behind the piston even if it stops quite at the end of its possible stroke.

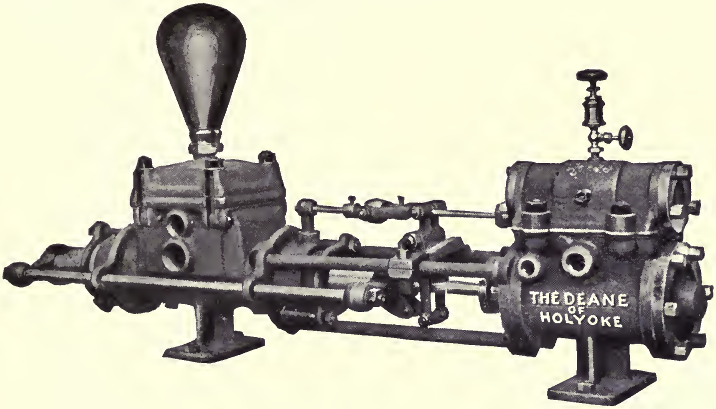


FIG. 44—SINGLE-CYLINDER, DOUBLE-ACTING STEAM PUMP

The ring on the valve rod which engages with the lugs on the steam valve is made to give a little lost motion in actuating the valve, thus securing a rest period at the end of each stroke, which gives smooth and quiet motion of the piston. Stuffing boxes are also used on the valve rods, these are packed with fibrous packing soaked in oil. The steam pistons have usually one or two packing rings of the same style as those used in a gasoline engine.

The steam-valve chest has a cover bolted down over a rubber compound gasket and a lubricator is screwed into this cover. The water piston as shown has fibrous packings which are easily renewed when worn out and the piston rod is packed from outside, a large gland with two bolts and nuts being provided generally.

The suction and delivery valves are placed immediately over the cylinder. Theoretically, higher efficiency would be gained by having the suction valves placed below the cylinder level, thus keeping the flow through the pump in as nearly a continuous direction as possible but for practical purposes the valve chamber shown is preferable, as it is then easily accessible and the cylinder is kept constantly primed.

The valves used for pumps lifting cold water only are usually of hard rubber although they are also made of brass with ground faces. In either case the seats are ground flat and true. A stud screwed into the metal in the center of the valve seat serves as a guide for the valve and also as a means for holding a spring which brings the valve back to its seat immediately the suction or pressure is relieved. Air chambers may be fitted on the discharge pipe but with a duplex pump are seldom necessary.

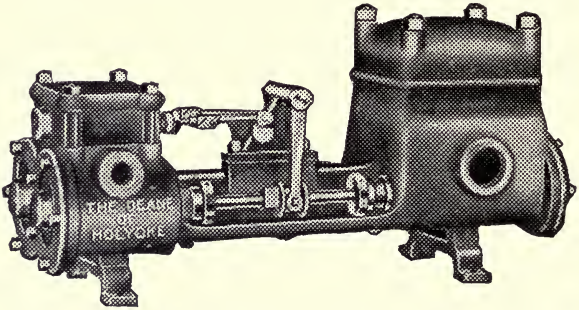


FIG. 45—TWO-CYLINDER STEAM PUMP

The difference in the plunger type of pump lies in the water end only. In this style the fibrous packed piston is replaced with a round end hollow plunger which is not a close fit in the cylinder. This in its motion displaces a certain amount of water at each stroke, thus causing it to open the discharge valve to relieve the pressure on one motion and on its return the suction valve to refill the space it occupied. A single cylinder plunger type pump is shown in Fig. 44. This has two plungers working in opposite ends of a water cylinder having a partition in the center. The plungers have stuffing boxes with glands held down by two bolts and nuts which are easily accessible for repacking. The two plungers are connected together by side rods of steel which are attached to crossheads. The water valves and chamber are identical with those described for the duplex piston pump but this illustration shows the use of an air chamber in addition. This is necessary on the single-cylinder pump if the lift is heavy as the discharge is not so continuous and water hammer is more likely to occur.

It will be noticed also that the steam valve is different in this illustration. This is because in none of the ordinary direct acting steam pumps is a rotary motion developed by means of which the valves can be operated as in an engine. The two-cylinder style differs in the conditions there, as has been shown, as each cylinder is caused to operate its neighbors valves. In a single-cylinder pump, however, it is necessary to reverse the piston by an impulse derived from itself at the end of the stroke. In an ordinary engine the valve would be moved only to the center of its motion where it would come to rest. Therefore this supplemental piston is used to move the main valve. The main and supplemental valves are of the slide type and easily accessible.

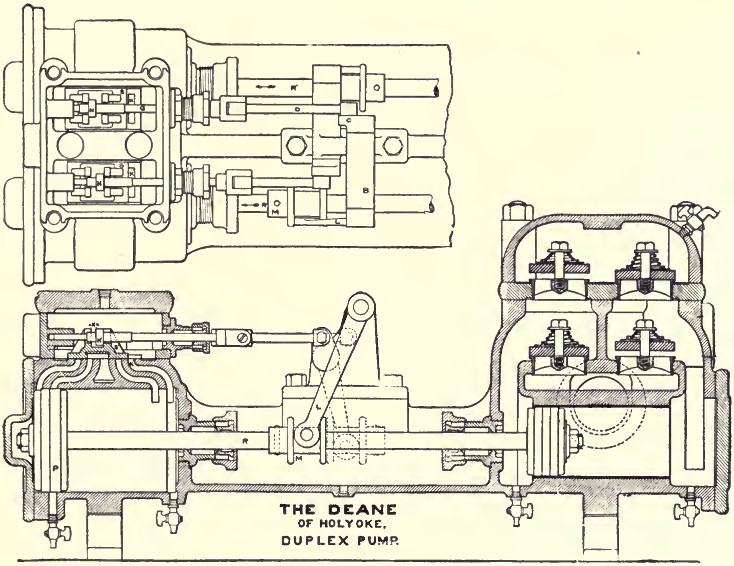


FIG. 46—SECTION THROUGH TWO-CYLINDER STEAM PUMP

An alternative method of operating the valves on a single-cylinder pump is to introduce a shaft and flywheel driven by a crank and yoke, with a crosshead in the rod between the steam and water cylinders. Thus a regular eccentric motion can be obtained to operate the valve rods, the inertia of the flywheel furnishing force to move the valve at the instant of reversal. The difference in the various makers' designs in steam pumps lies mostly in this valve action but these are for the most part minor differences, the principle remaining practically the same in all.

There is little need of entering into the question of boilers to supply steam for these pumps. The type in general use is the vertical multi-tubular boiler and its capacity must be determined by the size of the pump it is to drive and the nature of the fuel to be burned. It must of course be provided with the full complement of steam and water gauges, safety valve, water column, try-cocks, etc., and provision must be made for filling it by hand when cold, by means of a force pump or other device. An injector can also be fitted to be used when steam is available if desired. The method of piping the boiler connections will be described later.

Care of Steam Pumps.

It has been said elsewhere that there are conditions which favor the installation of a steam boiler and pump in preference to any other system. In a case where the fuel necessary is plentiful and cheap, or where the pump is to be run for long periods, the economy of the steam pump is apparent. There are also few delicate working parts and any man of ordinary intelligence can safely take charge of them. Also, where steam pressure is always available from a boiler supplying power to other machinery, a sawmill for instance, this is the most suitable type of water raising apparatus to install. The things which require chief attention are the lubrication, packing of pistons and the draining of cylinders.

In the sizes of pumps ordinarily required for water supply a grease cup or lubricator using heavy oil is generally used for the steam valves; the stuffing box on the steam end is lubricated well enough by the oil carried out by the piston rod. The other moving parts are lubricated as required.

Water pistons require packing occasionally, the number of times depending on the amount of work the pump is called upon to do. New packing should be carefully fitted and no more pressure on the glands, etc., should be applied than is necessary to compress the packing enough to prevent leakage.

That in the stuffing boxes should be renewed more frequently than the piston packings, as more pressure must be applied when it becomes hard, and consequently more friction is to be overcome by the piston. The discs of the water valves are easily removed and replaced when worn. The length of time they will stand depends entirely on the head they are working against and the amount of grit in the water. Troubles in running the pump may arise from time to time and it may be well to enumerate those most likely to occur together with their symptoms.

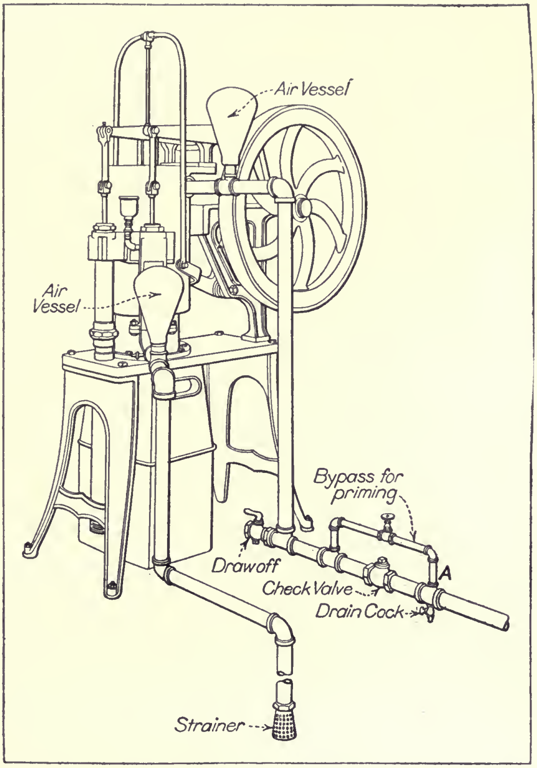


FIG. 47—HOT AIR ENGINE WITH CONNECTIONS TO PUMP

"Slamming" is due to several possible causes. The discharge valve may be stuck, the suction valve may have seized or the pipe become clogged with foreign matter from the water, the suction pipe may be too small, there may be a leak in the suction pipe or at the valves or joints at the pump.

Slamming may also be due to air in the pump. The pump may stick at the end of the stroke due to the stuffing boxes being too tightly screwed up or the valves not working properly. It may be that the trouble is noted only when the pump is started up from cold. Then it is likely to be due to the presence of condensed water in the steam cylinder.

If after opening the pet cocks on the steam cylinder the trouble is not removed, the unions and connections on the water end should be examined and any minor leaks made tight. Only after making sure that the cause of the slamming is not a faulty connection or water in the steam cylinder should the pump be taken apart. Should this be necessary the various possible causes should be taken up one by one and eliminated until the source has been reached.

The petcocks should be opened each night when the pump is stopped so that it will drain completely as it cools off. This is also a protection against the effects of frost should the pump be in a position where freezing might be expected.

When steam is being raised in the boiler, the safety valve or some petcock should be opened from time to time as steam is beginning to be made, so that all air will be relieved from the boiler.

When a duplex pump runs unevenly and one piston is making a longer stroke than the other it may be due to unequal pressure in the packing of the stuffing boxes, causing more friction on one piston rod than on the other, or to improper setting of the valve motion. As with other machinery the troubles which are likely to arise cannot be very definitely catalogued and the best advice that can be offered is to give as good care to the pump as possible and the troubles will be minimized at least.

Installation of Pumps.

In installing any of the pumps and engines of the different types described, certain provisions must be made, though these, of course, will vary according to local conditions. This applies especially to the location of the appliances. In most cases it will be found that the most satisfactory location for the engine and pump is at a point as close to the spring or brook from which the water supply proceeds as possible. Thus the suction pipe will be short and this is always a desirable condition to obtain. Care must be taken, however, that the water is protected from pollution by drainage of waste oil or other means and where a working head or direct-connected engine is placed directly over a well proper safeguards should be made.

The foundation for the engine and pump should be solid and constructed so as to avoid vibration. A gasoline engine or steam pump must be firmly bolted down. Concrete or masonry foundations with heavy bolts imbedded in them are best, but if timber must be used, it may be often arranged to have both engine and pump bolted to the same beams. Thus the danger of damage to gears by vibration and chattering is lessened.

Hot-air engines are much more free from vibration than steam or gasoline engines and do not call for such great precautions in setting. They should stand on a perfectly level foundation and have proper provision made to guard against fire from overheating of the floor below or around them.

Three illustrations are given of good methods of piping up gasoline and hot-air engines and steam pumps. Fig. 47 shows a hot-air engine with suction and delivery pipes and with air vessels on each pipe. A check valve placed on the delivery pipe as shown relieves the pump valves of much strain and will lengthen the life of the suction and delivery valves considerably. As it is often advisable to drain the water jacket and pump after pumping operations are completed a drain cock should be placed as shown. This admits of all of the water down to the check valve being drawn off and the petcocks at the pump and water jacket take care of the rest. The remainder of the pipe can be protected by boxing and packing in sawdust or by covering with insulating material.

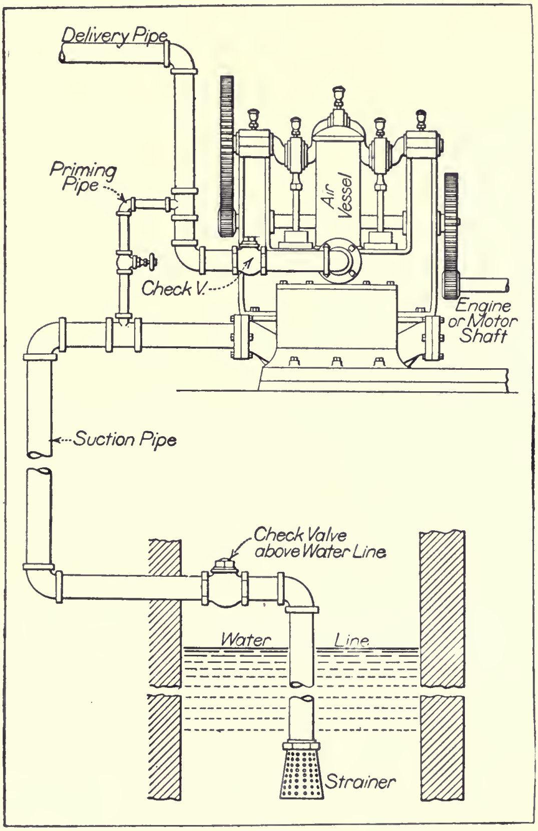


FIG. 48—TRIPLEX PUMP WITH SUCTION AND DISCHARGE CONNECTIONS

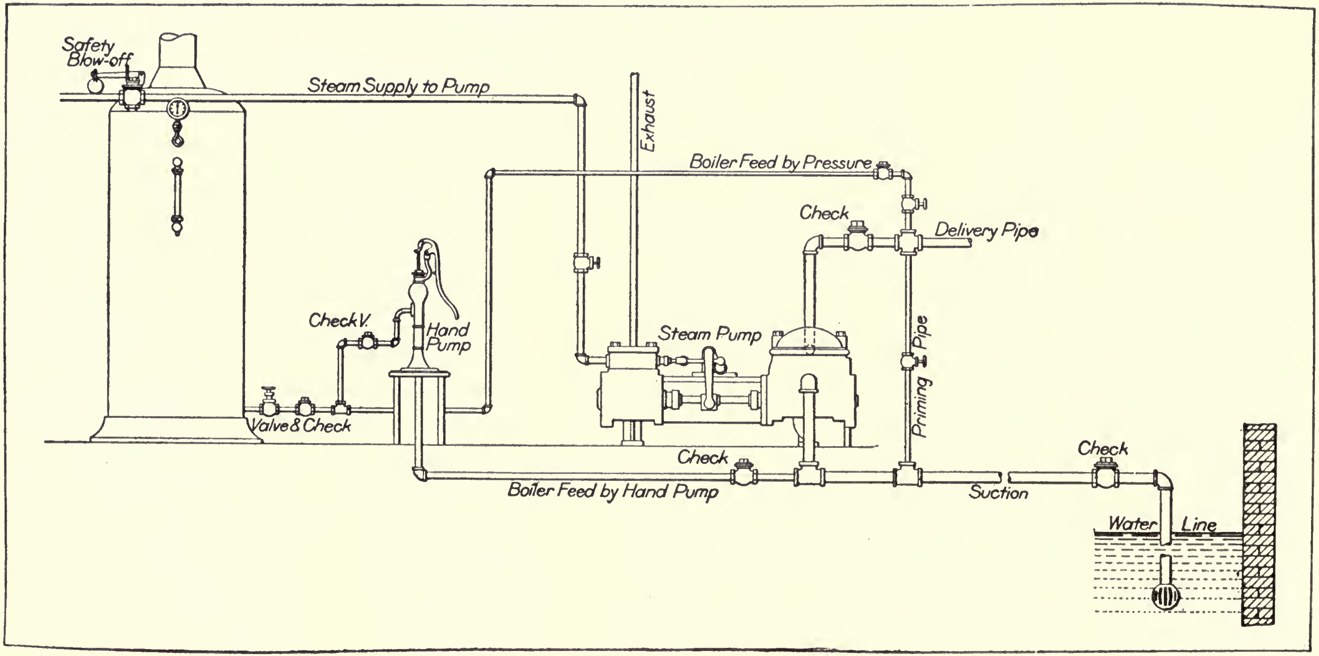


FIG. 49—TYPICAL CONNECTIONS TO STEAM BOILER AND PUMP USED FOR WATER SUPPLY

If it is desirable to empty the suction pipe also, a check valve above the water level should be used and a petcock fitted beside it. A by-pass pipe A makes a very convenient priming arrangement as water may be drawn back from the delivery pipe to refill the jacket and pump cylinder. Fig. 48 shows a triplex pump fitted in the same manner and for the same purpose.

If a gasoline engine with an evaporating-hopper jacket is used it is a very convenient plan to place a tee on the delivery pipe and to carry a small pipe to the hopper so that a small stream can be kept running to maintain the water at the correct temperature, or for refilling if necessary. Many engines are piped up so that a stream is taken from the delivery pipe and allowed to pass through the jacket and to waste instead of having a circulating tank in which case the connection would be made in a similar manner.

The piping arrangement for a steam pump is shown in Fig. 49 in connection with a small boiler such as is used in small water supply installations. An ordinary force pump is used to fill the boiler at starting and also if sufficient head is not available in the delivery pipe it may be used in maintaining the correct water level in the boiler. An alternative that meets the latter requirement is to fit an injector.

Some styles of steam pumps are fitted with hand levers so that the boiler may be filled when steam is not available and with this arrangement a by-pass is not absolutely necessary. Check valves must be fitted as shown and a valve behind the check on the boiler feed should always be fitted so that repairs can safely be made should any of them stick. A priming pipe is also used here to advantage, allowing of the entire draining of the pump and exposed piping and quick refilling and starting up again on the next occasion. The exhaust pipe may be carried back into the smoke pipe to increase the draft and the blow-off from the safety valve should be fitted in such a manner as to avoid stoppage.

CHAPTER VII.

HYDRAULIC RAMS.

Hydraulic power so far as it is applicable to the raising of water to higher levels can be developed in several ways. First, by the time-honored water wheel or its modern equivalent, the turbine; second, by the water lift which is an engine of similar construction to the steam pump, and thirdly, by the hydraulic engine or ram.

The first method is not very generally used as it entails considerably more expense than the second or third, without any noticeable increase in efficiency. The second method can only be used where an existing head of water of fair amount is available, and the use of this appliance is practically restricted to cities. It is used in raising water to the levels in lofty buildings higher than the head of water in the city mains is capable of reaching. It is also used to a considerable extent in raising "soft" or rain water from cisterns by means of the water supplied through the city distributing system. It has been computed that the comparative efficiency of water motors and rams is as follows, the theoretical power being taken as 1: Overshot water wheels, 0.68; turbines, 0.70; hydraulic rams, 0.60.

The Rife Engine Co. claims for one of its rams operating under a ratio of fall to pumping head of 1 to 8 an efficiency of 93.25 per cent.

Other makers give tables of efficiencies ranging from 38 to 80 per cent. under varying conditions, and these agree with the average given in the comparative table.

The simple hydraulic ram using the same water for power as that being raised is as simple and reliable a machine as could well be imagined. Its principle is that of using the inertia of a moving body of water (the head is secondary) to produce an oscillating motion in the column, the motion being sufficient to open and close a valve at the outlet of the ram and to force a portion of the water through the valve each time it opens. The illustration in Fig. 50 shows how this is effected in the simple type of ram.

In the illustration in Fig. 50 *A* is a large air vessel with a valve *B* in the bottom opening upward and having a pipe leading out of it at *C*. This air vessel with its valve is attached to a flanged opening or tee close to the extremity of a pipe *D*, termed the drive or injection pipe. Just beyond the air vessel and marking the extreme end of the drive pipe is a large valve *E* opening downward.

When the water is admitted from the reservoir to this drive pipe it will attain sufficient velocity in flowing through the valve *E* to raise it and close it sharply against its seat. The sudden closing of the valve causes a recoil of the water and a momentary increase of pressure sufficient to open the valve at the bottom of the air vessel and discharge pipe with consequent relief through this into the air vessel. The repetition of this a few times compresses the air in the air vessel and increases the head in the discharge pipe sufficiently to close the valve smartly as soon as the pressure in the drive pipe drops.

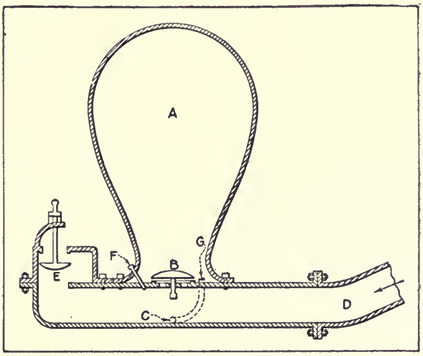


FIG. 50—DIAGRAM SHOWING CONSTRUCTION OF HYDRAULIC RAM

When the recoil takes place in the drive pipe the pressure is of course lowered in the extreme end of the drive pipe and against the valve *E*, and this at once drops back into the open position. As the static head in the drive pipe overcomes the recoil of the water, the motion is reversed and the column rushes back to close the valve *E*, opens the valve *B* for an instant and repeats the operation indefinitely.

At the instant of reversal of the flow in the drive pipe a slight vacuum is formed under the valve *B* and air is drawn in through a small snifter valve *F*. This replaces the air in the air vessel which is constantly being absorbed by the water in its passage through it. When the ram is not in use it may be drained by removing a plug in the pipe *C*. This is the regular type of ram and its general appearance is indicated in Fig. 51.

The outside appearance of a patented ram known as the Rife hydraulic engine is shown in Fig. 52. This is a ram of the single-acting type with some exclusive features. By moving the weight on the waste-valve lever, the stroke of the ram can be varied so that a short recoil with frequent opening of the valve or a slower and longer recoil may be obtained as desired.

It will be seen readily that the ratio of driving head to pumping head is a factor that is of the greatest importance in the placing of a ram, while the length of the drive pipe is also a factor of consequence. The proportion of water wasted to that raised is dependent on the relative heights of the fall and delivery and with a given fall the proportion of water delivered at the tank grows less as the height to which it is raised increases.

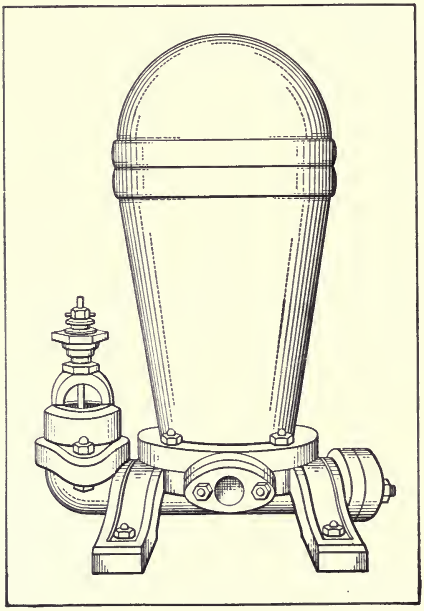


FIG. 51—REGULAR AMERICAN TYPE OF RAM

The length of the delivery pipe may also play a considerable part in lowering the quantity delivered owing to the effect of friction. One maker advises the use of a drive pipe of a length equal to three-fourths of the vertical height from the ram to the point of discharge or five time the height from the ram to the point of supply to gain the highest efficiency.

Where the ratio of the pumping head is great this method of calculating the length of the drive pipe might lead to error as a head of water at the ram of only two feet would give a drive pipe according to the rule of only 10 ft. long. This would be insufficient to ensure steady working if the pumping head was at all high and, therefore, the use of the three-fourths of the delivery height rule is more likely to give satisfactory results, and to provide a column of water with sufficient weight behind it to operate the valves satisfactorily.

The proportion of water wasted to that raised is from 7 to 2 upwards, that is, a ram under the most favorable circumstances may be expected to deliver two-sevenths of the water used and the proportion decreases as the driving head is lowered or the pumping head is increased. Thus if a ram raises 2 gallons out of every 7 passing through the ram to a point 40 ft. high it can raise 4 gallons 20 ft. or 1 gallon 80 ft.

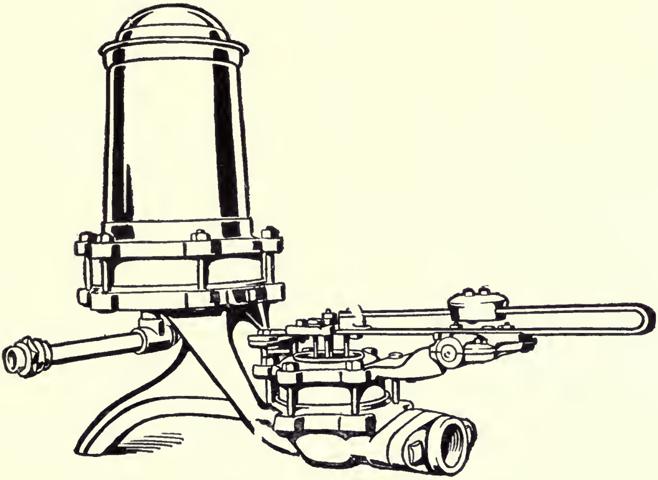


FIG. 52—THE RIFE HYDRAULIC ENGINE

To find the proper diameter of the drive pipe for a ram multiply the square root of the number of cubic feet of water available for use at the ram by 1.45. For the size of the delivery pipe multiply the numbers by 0.75. For instance:

If a streamlet flowing about 30 gallons per minute is available as a source of water supply it could be dammed and would supply a ram with a drive pipe up to 2.9 in. diameter according to the rule. It is worked out as follows:

$$30 \text{ gall.} = 4 \text{ cu. ft.} \qquad \sqrt{4} = 2 \quad 2 \times 1.45 = 2.9.$$

The size of pipe actually selected in such a case would be 2½ in., and multiplying 2.5 x 0.75 gives a delivery pipe size of 1.875 for which a pipe 1½ in. in diameter would be used.

The catalogues of the various makers give the capacities of the rams, and one could be selected with drive and delivery outlets within the sizes obtained by the rule, remembering that it is not good practice to use a ram larger than the requirements call for. If possible an air vessel of a capacity equal to the total contents of the discharge pipe should be used, but this is not always practicable if the delivery pipe is a long one. The reason is that there is less chance of failure through the vessel becoming waterlogged when the size is large.

A check valve placed on the discharge pipe at a point close to the ram will assist it considerably as it relieves the valves of much of the weight and prevents the air in the air vessel from being absorbed so quickly. The drive pipe should in every case be as straight as possible. If this cannot be arranged with a direct supply from the spring or brook to the ram, or if to gain a fair driving head an excessive length of drive pipe would be necessary, it is often possible to construct a small storage tank or standpipe at about the correct relative distance and elevation above the ram and to lead the water from the spring to it through tile or iron pipes. The drive pipe is then carried in a straight line from the tank to the ram.

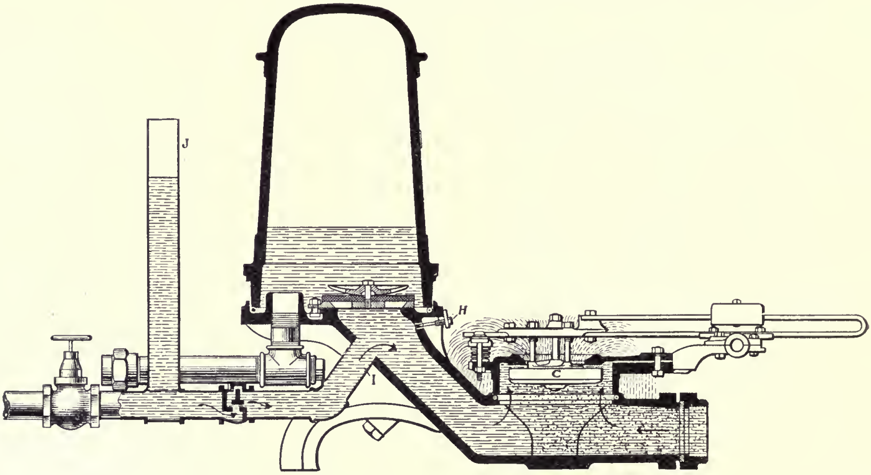


FIG. 53—SECTION THROUGH DOUBLE-ACTING RIFE RAM

When the supply of pure water is limited and a brook or other supply of water, even of doubtful quality is available, a ram of the compound or double-acting type should be used. These work in identically the same manner as the simple type, but an additional valve to which a supply from the spring is connected admits the spring water immediately under the valve at the base of the air vessel at the time of its opening.

As sufficient spring water is admitted at each stroke to replace that forced into the air vessel there is but a slight chance of the two mixing. The Rife Engine Co. states that the fall from the spring to the ram should be at least 18 in. and that the most satisfactory results will be obtained with a head of 2 ft. If not otherwise obtainable it places a standpipe on the supply to maintain this head and claims that if the check valve in the spring supply is kept in proper repair the delivery of pure water is certain.

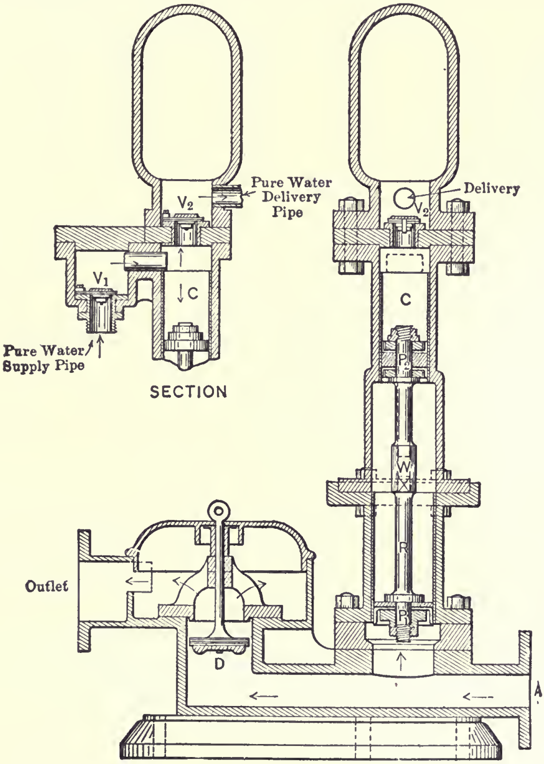


FIG. 54—ENGLISH TYPE OF COMBINED RAM AND PUMP

The construction of a double-acting ram is shown in Fig. 53, and the method of taking in the spring water will be evident from the illustration. A variation in the design is shown in Fig. 54. This is an illustration of a ram made in England and is a combination of ram and pump. The moving column of water, instead of utilizing its force directly upon the valve of the discharge pipe or causing another body of water to open the valve, operates in raising a plunger instead. This plunger is the piston of a pump to which spring water is introduced either by suction or gravity and with a set of suction and discharge valves of the usual type it raises water in proportion to the length of the stroke given the plunger by the ram below it. The plunger is assisted to regain its lowest position mechanically and the length and frequency of the stroke varies according to the height of the driving and pumping heads. A complete installation of a ram of this type is shown in Fig. 55.

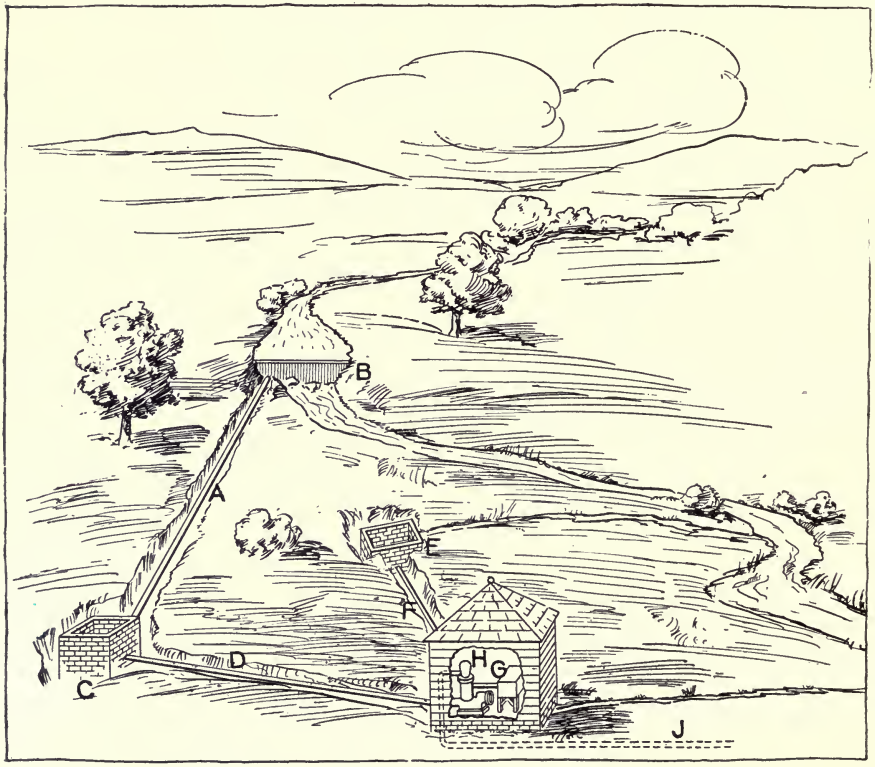


FIG. 55—COMPLETE INSTALLATION OF ENGLISH TYPE OF DOUBLE-ACTING RAM

CHAPTER VIII.

SELECTION OF A WATER SUPPLY, DETERMINING QUANTITY AND QUALITY. FILTRATION. RELATIVE CORROSION OF PIPES.

The selection of a water supply for a country residence or for any building in which the water may be used for drinking purposes calls for the exercise of common sense quite as much as exact science. It may be assumed that the source of the supply will be either a brook, a spring, a lake or a well and that the general characteristics of the water of the district are known before any selection of such a source of supply is made.

That is, if the water of the district is hard or alkaline, the general rule will be that such water will be encountered with exceptions according to the position in which it is found. Taking the rule, however, and neglecting the exception it is found that water taken from a spring or from a well is more liable to be hard or to contain mineral constituents than that taken from a brook of any pretensions, or from a lake, no matter how small. In the case of the brook or lake the water, while it may have proceeded from springs as its original source, is likely to be so diluted with surface water as to be comparatively free from minerals and, therefore, it is softer and better fitted for domestic purposes other than drinking than the original spring water.

This may easily be so and yet the water be totally unfit for consumption, for the runoff from the surface may have carried into the stream considerable quantities of organic impurities from cultivated land or from land upon which cattle have been grazing. The classification in point of safety and desirability of sources of supply has been made by many engineers as follows:

1. Water from deep wells.
2. Water from springs.
3. Water from upland brooks and lakes.
4. Water from shallow wells.
5. Water from rivers in populated districts.

The first classification pre-supposes that the water is free from organic impurities, although it may be highly impregnated with minerals. These latter, while harmless, may cause the water to have an unpleasant taste, or cause deposition of minerals in pipes and vessels on boiling. Therefore, this classification may have a sub-division and the most desirable water for domestic purposes may be said to be that which comes from the deep strata of the earth to the surface by means of a drilled well, but which is, so far, free from mineral impurities such as iron or lime in solution as to avoid incrustation of the pipes used to convey it, while having enough of such constituents to ensure that it will not be insipid like rain water.

The water of the second class, that from springs, is popularly supposed to be free from impurities or risk of carrying disease germs. Such, however, is not always true. The spring may be the outlet for water carried on a strata comparatively near to the surface and to which impurities from cesspool or farm buildings in the vicinity may possibly find access by percolation. In proof of this, it may be noted that a well in Connecticut was contaminated by gasoline which flowed through the bedding planes of sandstone rock for a distance of 225 ft. at a depth of 8 ft. from the surface. At two other points in Connecticut it was definitely proved that spring water was contaminated by sewage laden ground water. Therefore, the location of the spring from which it is proposed to take water in the relation to that of any buildings in the vicinity must be considered, together with the general topography of the neighborhood, to obtain the chances of its being polluted by water percolating through the upper strata or drift to rock joints and seams and so to the water horizon from which the spring is derived.

The third classification of water, that from brooks and upland lakes, is a wide one. These are also the sources from which most supplies of any consequence are derived. Undoubtedly, if the water from such sources is free from undue contamination it is the most desirable for general domestic purposes even if it is not so palatable as that from deep wells, as it is as a rule soft. This quality makes it most suitable for use in heating appliances as there will be practically no deposit of minerals, although, of course, there may be sedimentation due to vegetable or other matters contained in the water.

Soft water is always more desirable for laundry and general purposes, and for the supply of water to power boilers. In selecting the source of supply to any building, therefore, it is necessary to be assured that the danger of contamination by the surface flow from cultivated land or from tributaries to which polluted water may have access is negligible. Analysis of the water is the most conclusive and satisfactory assurance of safety, but if the district is one in which pollution is unlikely, and the topography such that it is not likely to occur at any future time, such a source of supply will be found to give all-round satisfaction.

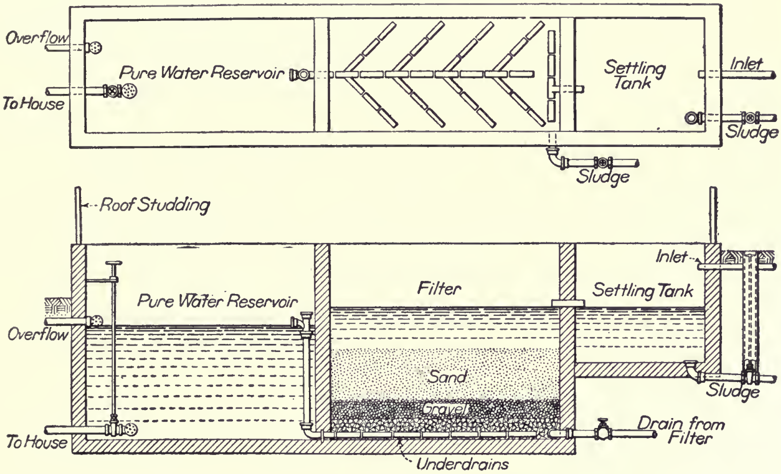


FIG. 56—PLAN AND SECTION THROUGH SLOW SAND FILTER

Determining the Potability of Water.

When the quality of water it is proposed to use for domestic or other purposes is doubtful, through the proximity of possible sources of pollution, it is advisable to make some test which will be conclusive. Undoubtedly an analytical test is to be preferred, but if this cannot be made conveniently, a mechanical test can be applied which will prove more or less satisfactory, and if the pollution is serious, the test will be quite conclusive.

For the purposes of the test salt in considerable quantities may be applied at the point of suspicion, which may be a cesspool, a surface or barnyard drain or even a house drain. If the water supply is liable to pollution from these sources the addition of salt to the water used for drinking purposes will soon become apparent.

Even a very slight pollution may be determined through the addition of salt, but as all water contains a certain amount of chlorine it is first necessary to ascertain the normal amount the supply contains and then afterwards the amount contained after salt has been applied to the places from which pollution is feared.

Thus analysis is required to afford satisfactory evidence of the purity of the water supply, but another method, purely mechanical, may be adopted, and as pollution of the supply will be evident even to the uninitiated, possibly this method is the more satisfactory. The material used in this method is fluorescein, and its effect is to discolor, or rather color, the water so that its presence is easily detected. It has no harmful effects on the water, but at the same time it is not advisable to use such a quantity that the water-supply will be subject to its addition for a longer period than is necessary. One advantage it possesses is that filtration through soil, chalk, sand, etc., does not affect the result it is intended to produce.

It is also detectable in very small quantities and it is said that one pound of fluorescein will, when dissolved in water by the aid of an equal weight of caustic soda, color 10,000,000 gallons of water. Therefore, only a very small quantity should be used in ordinary tests. The material is cheap and possibly the chief objection to its use is that when used incautiously and in too large a quantity, alarm may be caused to consumers, as the whole water supply taken from nearby sources may be discolored. Even then, of course, good would be the result, as evidence of pollution would be afforded.

Filtration of Water.

Filtration of the water may have to be resorted to where it carries much matter in suspension. There are two types of filters in general use, the slow-sand filter and the mechanical or rapid-sand filter. The first consists of a bed of fine sand and gravel placed in a tank built of concrete or brick and provided with a system of underdrains. Water is allowed to stand in the tank to a height of several feet above the sand, through which it slowly percolates. Sedimentation plays some part in the clarification of the water as the heavier particles settle on the surface of the sand, while the finer particles are removed in passing through the bed.

A gelatinous growth which in a short time coats the surface of the sand and fills to some extent the interstices, aids in the process, and also acts in the removal of bacteria to a considerable extent.

The flow of water is proportioned so that it will pass through the filter without disturbing the scum or film on the surface as if this is broken the rate of filtration will be uneven and the clarification therefore unsatisfactory. After a time this film becomes so thick that it is necessary to remove it, and to effect this about one-half to one inch of the top surface of the sand is removed, the filter refilled, and filtration resumed at a low rate, gradually increas-

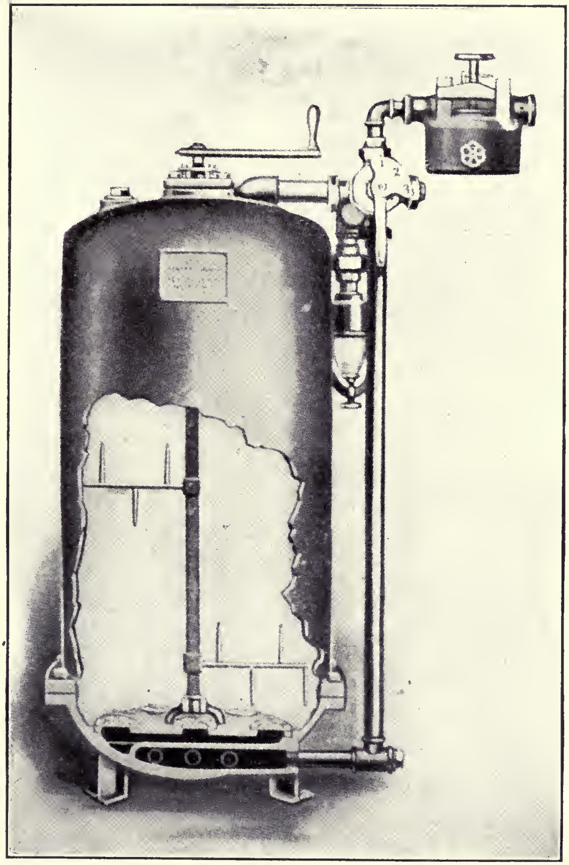


FIG. 57—JEWELL FILTER WITH COAGULENT FEEDER

ing the flow until it has reached its normal. In cold climates it is necessary to cover this type of filter so that it will not become frozen in winter.

The construction of a filter of the slow-sand type is shown in Fig. 56. The underdrains which are of perforated tile are laid on the floor of the tank and covered with graded stone over which is placed a layer of gravel. The stone and gravel are part of the underdrain system and do not add much to the value of the filter as a means of removing suspended matter. Over the gravel is placed fine clean sand to a depth of 4 ft. The sand should be sharp and free from clay, loam or lime. The rate of filtration which has been found satisfactory in such filters is about 75 gallons per square foot per day. From that the size of the tank and filter bed may be calculated.

The rapid sand or mechanical filter suitable for use in the smaller type of buildings is usually made of steel or cast-iron and consists of a chamber in which is placed a bed of sand of larger grain than is used in the open type. The water may pass through the filter by gravity or the filter may be of the pressure type, but in either it is common to use a coagulant to assist in the precipitation of the suspended matter. Alum is used and is added by means of a special chamber attached to the filter. Its effects on the water is to react on the carbonates it contains and to precipitate a magma of flocculent appearance.

As coagulation proceeds the particles of mud and silt in the water are drawn together and subside, and many of the bacteria in the water are removed in the process through entanglement in the coagula. Means are provided for stirring up the sand and for raking its surface periodically so that when the precipitant has become so heavy that the rate of filtration is interfered with to a serious extent the flow is reversed, the surface washed off, and the deposit removed.

Most surface waters contain enough lime in solution to make possible satisfactory coagulation when the chemical used is applied. Where the water is of low alkalinity, soda ash or lime water must be added to effect coagulation. The chemicals generally employed as coagulants are potash alum, alumina sulphate and sulphate of iron. The illustration in Fig. 57 shows a mechanical filter of the type suitable for use in a medium-size country institution.

Determining Available Supply of Water at Source and at Point of Discharge.

Before proceeding with the installation of a water supply system from a spring or a brook it is generally desirable to ascertain approximately the amount of water which will be available. To do this requires no special apparatus or care and the obviously simple plan of measuring the flow by a bucket will be resorted to in the first instance as a rule if the spring or brook is only a small one. To simplify the proceeding it is well to construct a rough dam in front of the spring, or across the brook, and in the dam a small pipe may be inserted. Having made sure that no water is escaping elsewhere than through the pipe the amount flowing per minute can then be arrived at without trouble.

TABLE FOR DETERMINING FLOW OF WATER FROM DAM

(In Gallons Per Minute)

Horizontal length of jet	1 in. pipe		2 in. pipe	
	6 in. LEVEL	12 in. LEVEL	6 in. LEVEL	12 in. LEVEL
6	7.01	4.95	27.71	19.63
7	8.18	5.77	32.33	22.90
8	9.35	6.60	36.94	26.18
9	10.51	7.42	41.56	29.45
10	11.68	8.25	46.18	32.72
11	12.85	9.08	50.80	35.99
12	14.02	9.91	55.42	39.26

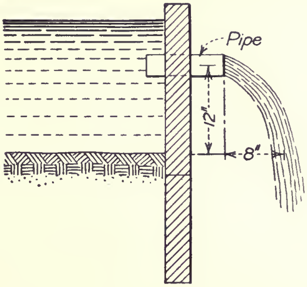


FIG. 58—TABLE AND DIAGRAM FOR USE IN DETERMINING FLOW OF WATER

If the brook is a large one a weir should be constructed. At its upper surface a board should be placed so that the water will pass over a relatively thin edge and this board should be carefully leveled. Then the depth of water passing over the weir and the speed of the flow may be ascertained and the number of gallons estimated from the figures secured. Thus if a weir was 2 ft. wide and a depth of 1 in. of water was passing over it at the rate of 25 ft. per minute there would be a total of 24 x 1 x 300=7200 cu. in. of water passing over the weir each minute. This is equal to a flow of 31.2 gallons per minute.

A simple method of determining the flow of water from artesian wells of the flowing variety or from springs and other sources where a pipe can be suitably applied was described in a bulletin by Professor J. E. Todd. By measuring the distances indicated on the diagram in Fig. 58, a near approximation of the water passing through the pipe may be arrived at on consulting the accompanying table. In using this method the measurements should be taken in still air as the pressure of the wind may be sufficient to vitiate the results to some extent.

If the water from a flowing well is to be measured, an elbow should be screwed on the top of the pipe from which the water issues. If the water comes from a spring or a brook a dam should be made as already described. In the front of the dam the pipe conveying the water should be placed, and this should be put in so that it lies in a perfectly horizontal position. To measure the flow the distance from the center of the opening of the pipe to the center of the column of water at a point 6 in. or 12 in. below the level of the pipe should be taken. For example, if the pipe through which the water flows has an inside diameter of 2 in. and at the 12 in. level the horizontal distance from the face of the pipe to the center of the falling column is 8 in., a flow of 26.18 gallons of water per minute will be indicated by the table. If the horizontal pipe is 1 in. in diameter and the distance at the 12 in. level is 8 in. a flow of 6.6 gallons per minute will be indicated. The pipe through the dam should be short, else some variation in figures may be experienced.

When fractions occur in the measurements secured, the number of gallons can be obtained by averaging the figures for the next lowest and highest whole numbers in the table. If the pipe used is not of the diameters mentioned in the table, the amount of flow can be ascertained by using the following factors:

Assume the pipe to be 1 in. and ascertain what the flow would be with the measurements secured. Then,

For ½-in. pipe multiply discharge of 1-in. pipe by 0.25.
For ¾-in. pipe multiply discharge from 1-in. pipe by 0.56.
For 1¼-in. pipe multiply discharge from 1-in. pipe by 1.56.
For 1½-in. pipe multiply discharge from 1-in. pipe by 2.25.

Flow of Water in Pipes.

After the amount of water available at the source of supply has been ascertained the size of the pipes required to convey a given quantity per hour must be computed. The factors controlling the flow of fluids through pipes of comparatively small diameter in proportion to their length consist of pressure, which may be due to gravity or static height, and the retarding influence of friction.

The velocity with which the water flows in the pipe affects the amount delivered inasmuch as the friction increases nearly as the square of the velocity. Likewise the loss of velocity due to friction is exactly in proportion to the length of the pipe with equal velocities throughout. Certain other elements affect the friction and consequent loss of velocity beside length and diameter of the pipes. The roughness of the interior surface, uneven grading and high spots in the line where air liberated from the water may collect, all tend to increase the frictional resistance to the flow.

In order to utilize the full flow of water from a reservoir or suction tank, by gravity, pressure or suction, the entering end should be enlarged, and if a strainer is used the free area should be somewhat in excess of the area of the pipe to which it is attached.

Eytelwein's formula which may be used with satisfaction in ascertaining the flow of water through long pipes is as follows:

$$W = 4.71\sqrt{\frac{D^5 \times H}{L}}$$

in which

W = cubic feet of water per minute.
D = the diameter of the pipe in inches.
H = the head of water in feet.
L = the length of the pipe in feet.

For example, it is desired to ascertain the number of gallons of water which will be conveyed through a pipe 2 in. in diameter 1000 ft. long, and with a head of 100 ft.

The equation would appear as:

$$4.71\sqrt{\frac{2^5 \times 100}{1000}}$$

The fifth power of 2 is 32 therefore: $\frac{3200}{1000} = 3.2$

$\sqrt{3.2} \times 4.71 = 8.42$ cu. ft. per minute or 62.98 U. S. gallons.

The effect of friction in long pipes may be noted by assuming that a head of 25 ft. only is available. With this head the flow would be only 4.21 cu. ft. per minute or 31.4 gallons. Thus while the pressure in the first instance is four times that in the second the amount of water delivered is only twice as much, showing that the frictional resistance is the main factor to be considered in estimating the size of the pipe required.

The velocity of flow may be computed from these figures by dividing the volume in cubic feet by the pipe area in square ft.

Alternatively the rule may be used as: $\dfrac{\text{Volume} \times 144 \text{ sq. in.}}{\text{Pipe area in sq. in.}}$

when the equation would appear as: $\dfrac{8.42 \times 144}{3.1416} = 386$ ft. per minute or 6.43 ft. per second.

If the head were 25 ft. there would be a velocity of 192 ft. per minute, or 3.2 ft. per second.

The friction loss in a pipe line carrying water by gravity is involved in the terms of the equation for flow, and all that is required to arrive at the sizes necessary, or the amount delivered, is to change the diameter of the pipe in the equation. This applies to all of the standard pipe sizes.

Where the loss of head or pressure on pumping lines is to be ascertained and where an approximate velocity may be known from the speed of the pump, use the formula $C \times \dfrac{L}{D} \times \dfrac{\text{Velocity}^2}{5.4} =$ friction head in feet, which divided by 2.3 = pressure per square inch in the water cylinder of the pump to overcome friction.

C is a coefficient that decreases with the velocity of the water and is

For 1 ft. per second 0.0317
For 2 ft. per second 0.0266
For 3 ft. per second 0.0244
For 4 ft. per second 0.0231
For 5 ft. per second 0.0221
For 6 ft. per second 0.0215

with proportional differences for fractions of 1 ft.

D = diameter of pipe in inches.

As in the previous example with a 2-in. pipe 1000 ft. long and 25 ft. head, the equation would appear, if it were required to pump 31.4 gallons or 4.21 cu. ft. per minute:

$$0.0241 \times \frac{1000 \text{ ft.}}{2 \text{ in.}} \times \frac{10.24}{5.4} = 22.77 \text{ ft. head} = 9.9 \text{ lb. per sq. in.}$$

for friction alone, to which must be added the pressure due to elevation.

The friction and loss of head due to elbows in the line may be ascertained as follows:

For the loss of head due to each elbow $\frac{\text{Velocity}^2 \times 0.98}{\text{Twice gravity}} =$ loss of head per elbow, 0.98 being a coefficient and twice gravity = 64.33.

Therefore if there were 6 elbows in the line of 2-in. pipe 1000 ft. long, through which 4.21 cu. ft. of water per minute is to be pumped to a height of 25 ft., the friction of elbows may be found by:

$\frac{10.24 \times 0.98}{64.33} \times 6 = 0.936$ ft. head, or 0.4 lb. pressure, to add to the friction head, making $9.9 + 0.4 = 10.3$ lb. per sq. in. total friction loss between the pump and the point of discharge.

To find the horse power of a pump to raise a given amount of water to a known elevation:

Multiply the number of gallons per minute by 8.35 (weight in pounds of one gallon) and this result by the total number of feet plus the height represented by friction loss in the pipe, and the work in foot-pounds is known. Divide the result by 33,000 to ascertain the horse power.

For example, where it is desired to raise 31.4 gallons per minute to a height of 25 ft. through a pipe 1000 ft. long.

It has already been shown that the total friction loss in such a pipe, when it has been necessary to use 6 elbows, is 10.3 lb. per sq. in. corresponding to a head of 23.7 ft., therefore $31.4 \times 8.35 \times (23.7 + 25) \div 33{,}000 = 0.387$ H. P.

Loss of Head. Cause of Air Locking

The loss of head due to irregular grading of a pipe line so that there are high places and alternate dips or pockets is a factor which is of importance in systems where a low head is available for a gravity supply. Unless the grading is such as to eliminate air pockets or a sufficient pressure is available to overcome the resistance to the flow entailed, there will be trouble from "air locking." The effect of such pockets may be seen from the following and by reference to Fig. 59 which shows in diagrammatic form the resistance due to air pockets.

The diagram represents a water tower 25 ft. in height supplying water to the point *F*. In order to reach that point it is necessary to rise over two elevations of 10 ft. each and 1 of 3 ft. The pipe line, therefore, is represented as having two rising columns of 10 ft. each, *A* and *C*, and one of 3 ft. at *E*. To realize the effect these columns have on the discharge at *F*, imagine the water rising slowly in the tower. As soon as it begins to rise in the tower, it rises to a corresponding height in the column *A*, trickles over the top and rises in *C*. It rises in the column *C*, however, only as far above the bottom as the water level in the tank is above the top of *A*, and in consequence until the water-line in the tank has reached a height of 20 ft.; air is trapped in the column *B* and no water passes over the top of the column *C*.

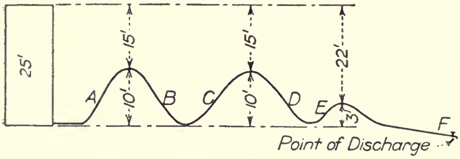


FIG. 59—DIAGRAM ILLUSTRATING CAUSE OF AIR LOCKING

In turn it does not pass over the top of *E* until the water-line has risen to a height of 3 ft. above that of the point at which it passed into *C*. In other words, the initial pressure required to carry water to the point of discharge is that equal to a head of 10 ft. + 10 ft. + 3 ft. and as the total head available is only 25 ft. there is only an available head of 2 ft. at the top of the column *E* until the air has been removed from the top of the column *C* and discharged through *E*. As soon as the pipes are free from air and water has risen in each of the columns there is an available pressure at the point of discharge equal to that at the top of the first column over which the water has to pass; namely, 15 ft.

After the system has been in use some time air is liberated by the water, collects in the high parts of the line and gradually the supply is restricted. If there should be a sufficient number of rises to equal the available head the supply will cease. If for instance, the column *E* were 5 ft. high no water would pass through to the point of discharge until the air had been removed from the top of the columns *A* and *C*.

In designing gravity or pressure supply systems, therefore, it is necessary to make allowance for the lost head when the line is carried over several rises before reaching the point of discharge.

Data Relating to Water.

Pure water consists of 2 parts hydrogen and 1 part oxygen. Chemical symbol HO. It is a colorless, tasteless, odorless, transparent liquid and is practically incompressible. Water freezes at 32 degrees F. and boils at 212 degrees F. at sea level. At its maximum density (39 degrees F.), it is the standard for specific gravities and 1 cubic centimetre weighs 1 gramme.

A column of water 1 in. sq. and 2.31 ft. high weighs 1 lb.

A column of water 1 in. sq. and 1 ft. high weighs 0.433 lb.

A column of water 33.947 ft. high equals the pressure of the atmosphere at the sea level.

One lb. per sq. in. equals a column of water 2.31 ft. in height.

0.433 lb. per sq. in. equals a column of water 1 ft. in height.

Water is an almost universal solvent; consequently pure water supply is restricted. If there should be a sufficient number of rises to equal the available head the supply will cease. If for instance, does not occur in nature. Sea water contains nearly every known substance in solution.

Doubling the diameter of a pipe increases its capacity four times. Friction of liquids in pipes increases as the square of the velocity.

The mean pressure of the atmosphere is usually estimated at 14.7 pounds per square inch, so that with a perfect vacuum it will sustain a column of mercury 29.9 inches, or a column of water 33.9 feet high.

To find the pressure in pounds per square inch of a column of water: Multiply the height of the column in feet by 0.434. Approximately, we say that every foot elevation is equal to ½-lb. pressure per square inch; this allows for ordinary friction.

Corrosion of Underground Water Pipes.

All of the metals in common use for the conveyance of water in underground pipes are subject more or less to corrosion from the influences of the soil in which they are laid, as well as from within. The metals from which water pipes are made are lead, iron and brass. The latter is not used to any great extent underground as it does not possess any marked advantage over lead for cold-water supply and is much harder to lay, especially if the ditch in which the pipe is laid is excavated in rough and stony ground.

Iron pipe, when heavily coated with zinc, or galvanized as the term is, is capable of giving long service under favorable conditions. These are, dry, clean soil, free from building refuse such as concrete, cinders and the like, and a straight ditch with a constant grade. If the pipe is forced into a crooked ditch or if bends are made on the pipe when it is in position there is always the danger existing of putting too much strain on the threaded joints, and while they may not show any ill effect at the time they are liable to give trouble by breakage at a later time. Also, if the soil is loose and there is heavy traffic over the ditch, or if the ground should become frozen to a depth which makes the ground solid practically to the line of the pipe, joints may become broken through an excessive weight passing over it.

Lead on the other hand has none of these disadvantages as it is a soft and pliable metal and yields readily as the soil settles, or as a weight passes over it. In some respects this is a disadvantage as by its yielding it may settle into pockets, and where there is little pressure this may lead to air locking with interruption in the supply. Its pliability, however, makes lead eminently suitable for use in ditches where the presence of rocks or the necessity of avoiding obstacles of another nature cause the pipe line to assume a tortuous path. Then a lead pipe may be rolled into the ditch with the greatest of ease, while it would be necessary to make difficult bends of a pipe of harder metal or to use a complication of fittings and short pieces of pipe.

Corrosion of Lead Pipe.

Regarding the relative liability to corrosion of lead, iron, and brass pipes laid underground, it may be said that for all general purposes and in all average conditions lead will give the best service. The metal is not at all affected by dampness unless the earth in which it lies also contains lime. Then in conjunction with moisture a corrosive action is established.

The word "corrosion," as applied to lead or any other metal, must be considered a relative term. Thus, when it is stated that lead corrodes under certain conditions, it is important that the rate of corrosion should be compared with the rate of corrosion of other materials, as otherwise the expression is practically valueless. To measure the relative desirability of a certain material for a certain use, all of the advantages and disadvantages should be considered with regard to each material used, and all the factors affecting corrosion should be considered, together with the ease with which they can be eliminated or controlled. This is a general proposition which too often is lost sight of in considering engineering problems. Very often a material is condemned or criticised without due regard to the value of its other properties and the ease with which the quality criticised can be corrected.

Lead, for instance, has valuable properties which altogether outweigh its liability to corrosion under conditions which are exceptional. The conditions under which corrosion may be expected from the outside are these:

Where the pipe is laid through "made" ground in which large amounts of building refuse such as old mortar or broken concrete, cinders, organic refuse of an animal or vegetable nature, old iron, cans and other refuse has been deposited.

In passing through walls or concrete floors, where the pipe has been laid in close contact to the mortar or concrete without protection of any kind.

In floors of which the base is cinders and in which the lead will be subjected to the action of the sulphur contained in the latter.

In land containing a large amount of natural salts such as may be met with in a limestone district.

In all other conditions lead will last indefinitely and in these exceptional conditions a coat of asphalt or protection by boxing will obviate the trouble.

From the inside, lead is attacked by water of a very soft nature, the purer the water, the greater the action it has on the metal. If the water is hard, that is if it contains sulphates or carbonates of lime, very little action will take place on lead pipe through which it flows, as these form a film on the metal which prevents further corrosion. Experiments in Europe have shown that where lead has been alloyed with a small proportion of tin very soft waters have had no effect on the pipes made from the alloy. It has also been customary to use tin-lined lead pipe in some parts where the water had a detrimental effect on lead exposed to its action.

Corrosion of Iron Pipe.

It has been stated that the term corrosion must be taken as a relative term and, therefore, it may be said that the rate of corrosion of iron as compared with that of lead depends entirely upon local conditions. Some waters seem to have a quicker action upon iron than others. One theory for rapid corrosion is that where much air is carried in solution in the water and an opportunity is given by a relief in pressure at any part, such as occurs when faucets are opened on a service line, the air is liberated and its effect in hastening corrosion is considerable. Another theory is that the principal cause is the growth of vegetable matter of minute size. It has been demonstrated that iron bearing waters will precipitate crenothrix or other algae in the pipes in which it is conveyed and that the action is accelerated by heating the water. This is known to all plumbers as the fact that iron pipes corrode more rapidly on the hot-water system than on the cold-supply lines is generally admitted.

It has also been noted that where water is filtered and coagulants added to precipitate the impurities or sediment conveyed by the water the corrosive action is more pronounced. Not only that, but waters carrying vegetable matter such as peat which have little action on iron or lead pipes will have a decided action on the latter metal after it has been chemically treated in a filtration plant to remove the coloring matter.

The conditions under which corrosion may be expected from without the pipe are virtually the same as those which affect lead pipe. Iron pipe will not be affected to anything like the same extent by the presence of lime in the soil, but moisture and the action of the atmosphere together corrode it rapidly. Also cinder concrete is very destructive to it, and, consequently, wherever pipes pass through a concrete wall or where they will be subjected alternately to the action of moisture and the atmosphere, some sort of protection should be given them. A heavy coat of galvanizing will add many times to the length of the life of the pipe. In addition. where it passes through material likely to affect it a coat of asphalt should be given it.

Corrosion of Brass Pipe.

Brass pipe is little affected by moisture and the ordinary conditions to be expected underground, but decaying organic matter will destroy its life in a short time. It is also subject to galvanic action and should the right conditions be set up this latter will be more destructive than it would be to iron or lead. For instance, if a lead pipe is joined to the brass pipe by a wiped joint and the connection is subjected to the action of liquids seeping from a leaky house drain or from a barn or other outbuilding housing animals, there will be a positive action between the two metals which in a short time will lead to the eating away of the tin on the brass pipe where the wiped joint is made and a leak will develop. In addition the brass pipe will probably become brittle and may break when any heavy traffic passes over it.

Such conditions are also abnormal and, therefore, have to be considered as such. The metal in ordinary conditions is more elastic than either iron or lead. It resists corrosion from within satisfactorily and can be bent easier than iron, while the same type of fittings may be used to make the connections and thus it is better adapted for certain conditions than lead while it is more lasting than iron.

CHAPTER IX.

WATER SUPPLY FROM WELLS AND SPRINGS. METHODS OF RAISING WATER.

In many sections of the country practically the only source of water supply is a well. Wells are of three types, the artesian or drilled well, the driven well and the dug well. The first is easily the best and as a rule the water supplied by it proceeds from the deep strata of the earth and in consequence is already filtered and free from organic pollution. The second and third types of well are less desirable as they simply draw water from the upper strata and if in closely built up sections there is grave danger of pollution from cesspools, leaky drains, garbage heaps and stables. The driven well is convenient and inexpensive. It consists simply of a pipe to which has been attached a tapered point perforated with a number of holes of small diameter. This is driven into the earth until a water-bearing strata is reached, and as this may be only a few feet from the surface the danger of contamination of the water is obvious. The same may be said of the dug well and unless they can be located so as to be safe from contamination they should not be tolerated.

The illustrations in Figs. 60 and 61 show wells of these types. One convenience of the driven well is that it may be sunk in batteries. This affords a better opportunity to collect a good supply of water as the well points may penetrate the water horizon at several different points and thus the supply will not be lowered so rapidly as to cease, or to provide water at intervals only. The driven well has the advantage over the dug well that the water is at least kept from contact with other forms of pollution such as the dug well is subject to. The latter should always be provided with a curb to prevent ingress of surface water and it should be covered to prevent access by vermin or insects. Either of them should be located so that the natural drainage of the surface will flow away from the well rather than toward it. A battery of driven wells connected so as to provide a large supply for fire purposes is illustrated in Fig. 62.

Catch Pits at Springs.

In collecting water from a spring it is usual to build a small catch pit of brick or concrete in such a fashion that the water will rise readily within it, and to keep the walls of the pit high enough to ensure that surface water will not find access. If the spring rises through a fissure in the rock the pit is easily made water-tight by concrete placed around the bricks which form the foundation, or by the concrete of the walls if this form of construction is used. If the spring is rising through sand from a hardpan strata, or there is a body of clay which it is not desirable to remove to reach the harder strata, it is often well to pack around the outside of the walls with clay, or "puddle" as it is often termed. This will effectually prevent the ingress or egress of water and the spring will then rise to the desired level in the catch pit.

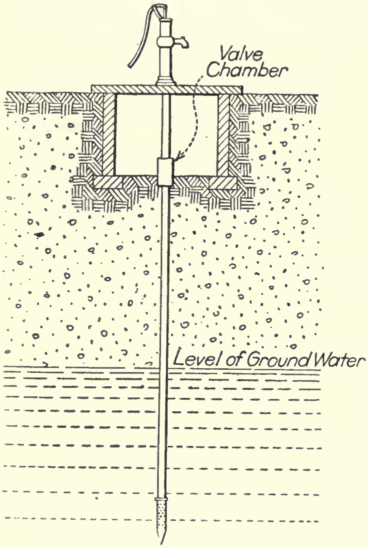


FIG. 60—DRIVEN OR PIPE WELL

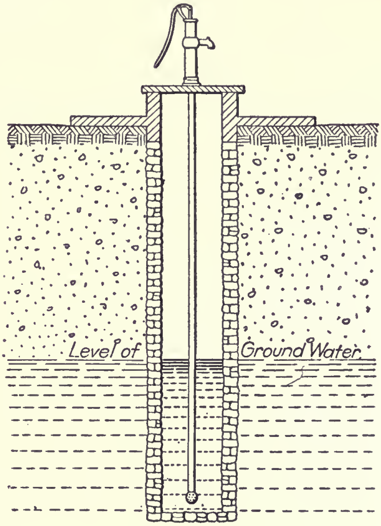


FIG. 61—SHALLOW OR DUG WELL

If several springs appear at the surface in approximately the same location they may be enclosed in one catch pit or separately walled and connected into one central reservoir from which the supply to the buildings may be led. If a catch pit of large area is constructed it will afford a supply of water of sufficient volume to ensure that an extra heavy draught for a short period will be taken care of, but such a catch pit cannot be looked upon as a reservoir. It is apparent that as the ground-water level falls in dry seasons the level will fall in the catch pit until it may eventually disappear. Therefore, if it is desired to store water in large quantities a reservoir must be constructed which will have a water-tight bottom as well and to this the supply from one or more small catch pits may be led.

Such a reservoir is illustrated in Fig. 63 with the leading pipes from two small catch pits built over springs close by. It will be seen that the reservoir is constructed on the hillside at a lower level than that at which the springs appear, the assumption being that by constructing it there less danger of tapping the water-bearing strata will be encountered, with the attendant risk of losing the springs through providing an easier outlet for the water, an outlet which might possibly mean access to some fissure which would lead the water to another level difficult or impossible to locate. The nature of the ground, however, will determine largely the risks that will be taken on this account.

Where the soil is of a gravelly nature the risks are greater than where the rock is near to the surface, or where the springs which are to be utilized are located in a hollow which is the natural point to which water will flow.

It is well to provide a sludge pipe with a valve which may be reached conveniently so that the water may be run off from time to time. This pipe should be put in at the lowest point, the floor of the reservoir being pitched thereto in order that it may be swept out in process of cleaning. If the supply to the buildings is by gravity, it should leave the reservoir at a higher level, generally some 6 in. above the floor, and the outlet should be provided with a copper or brass strainer. If a vent pipe is fitted on the house side of the control valve it will admit air and so allow the water to be drained from the pipe. This is a particularly desirable feature in installations at summer homes where the water is shut off during the winter months, as then the whole line may be drained and so safeguarded from the effects of frost.

Strong covers should be fitted over the catchpits. Iron covers are best for this purpose and if they are located where they may be tampered with padlocks should be provided. The reservoir, if of concrete, may be roofed over with the same material. A few steel rails laid over the walls and some wire reinforcement is all that is necessary to provide the support for a substantial flat roof which can in turn be covered over with earth and turf if desired. A supply of thoroughly cool water is then assured.

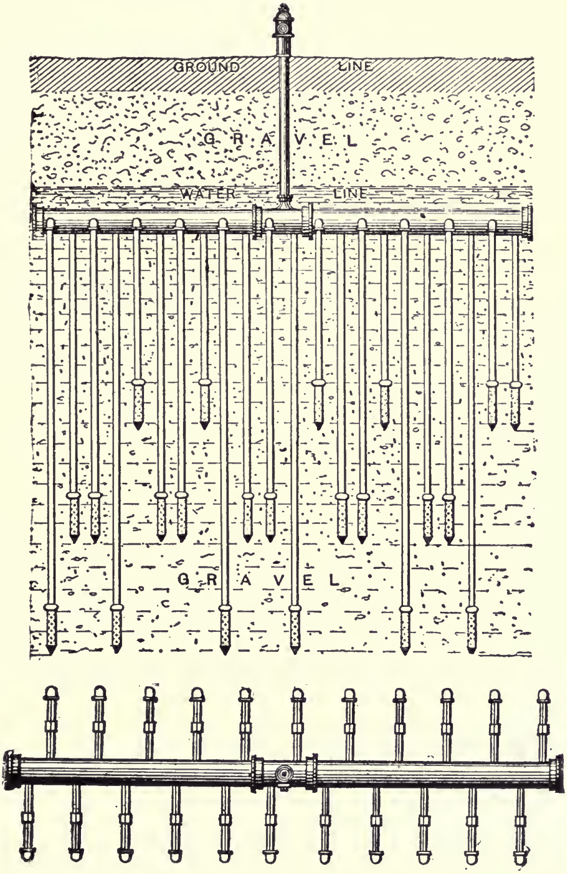


FIG. 62—BATTERY OF DRIVEN WELLS CONNECTED TO FIRE HYDRANT. PLAN SHOWS LOCATION OF FEEDERS

Raising Water from Deep Wells by Compressed Air.

The appliances generally used in connection with the non-storage type of pneumatic water supply cannot be used satisfactorily in deep wells and where compressed air is to be utilized in raising water from drilled wells of considerable depth a special method of casing is resorted to.

The system possesses several advantages over that of pumping as there are no valves or long-pump rods to become inoperative. A compressor and air storage tank with the necessary control valves are all that are required and the application of the pressure is made through a pipe of small diameter carried beside the water supply pipe. The air pipe is carried nearly to the bottom of the well where it enters the conducting pipe as shown in Fig. 64.

The air pipe is usually arranged to follow closely along and outside the discharge pipe to its lowest extremity, where it is fitted with a return bend and nipple. It will be observed that the air from the receiver is thereby discharged upward directly into the bottom of the water discharge pipe. It has been the practice of some engineers to attach a brass nozzle at the extremity of the air pipe. Various styles of these are offered, some being patented, for which the makers claim decided advantage; but it has been ascertained that in this case nothing is better than something (anything). A free discharge of air directly into the foot of the suspended discharge pipe is all that is necessary.

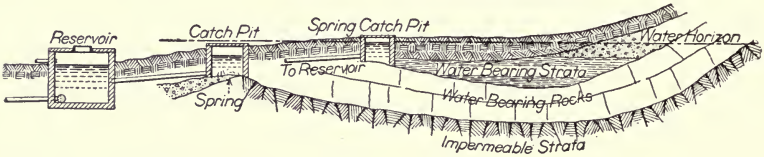


FIG. 63—SPRINGS FROM ROCK AND TILL CONDUCTED TO RESERVOIR

The effect of discharging highly-compressed air into the bottom of the discharge pipe is to displace some of the water in it, lessening the gravity of what remains until overcome by the greater pressure of the solid column of water outside of the discharge pipe within the well. Both the air and water in the suspended pipe are forced upward by this resisting pressure and discharged at the top of the well or outlet of the suspended pipe. It will therefore be apparent that as long as there is sufficient depth and flow of water into the well to constantly refill the discharge pipe, and air is supplied to reduce the gravity of that in the discharge pipe, the operation, as described, will continue.

There is, however, one important condition to the successful operation of the air lift system. There must always be ample depth

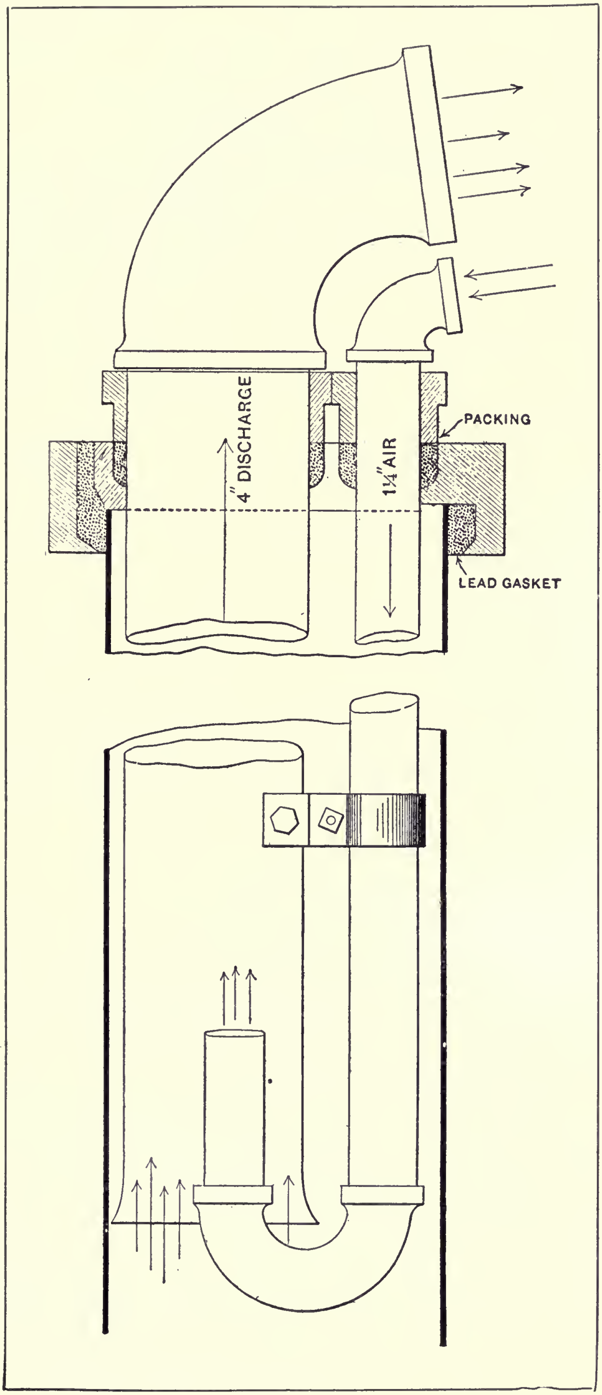


FIG. 64—CONSTRUCTION OF AIR LIFT AT CURB AND LOWER END OF CASING

of water in the well to insure sufficient resistance at the foot of the discharge pipe to force the lightened column inside the discharge to the top of the well. This is termed "submergence."

Well informed engineers who have made a study of the system say the submergence should be 50 to 60 per cent. By this is meant 50 or 60 ft. of water to each 100 ft. depth of total lift. That is, if the well is, say, 200 ft. deep, and it is desired to discharge the water into a tank situated 50 ft. above the top of the well, there must be not less than 125 ft. (50 per cent. of 250) to 150 ft. (60 per cent.) of water in the well at all times. A less depth would probably render the system useless, as the resisting pressure would be insufficient.

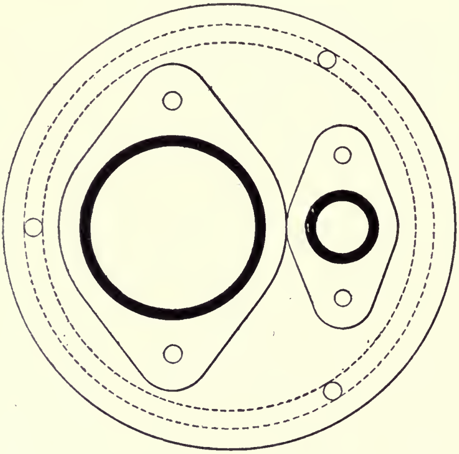


FIG. 65—PLAN OF CAP AND FLANGE AT WELL HEAD

It is customary to discharge the water directly into a tank or receiving basin situated immediately above or closely alongside of the well, with very short, if any, lateral conveying pipes.

As indicated in Fig. 64 the casing is closed at the top by a cast-iron cap through which the pipes are passed, the joints being made by molten lead firmly calked, and also by a gasket and gland as indicated in Fig. 65. If the well is located in a river bed or lake where the water is to be taken from the strata beneath the sand and gravel forming the bottom of the lake or bed of the stream, a double casing is used. The outer and inner casings are sealed at the top and at a point far enough beneath the stream bed level to ensure proper filtration of the water through the sand bottom, the outside casing is perforated by small holes. The inside casing is perforated in a similar manner, but at a lower level so that the water passing down from the river or lake will enter the inner casing freely.

With this system the discharge is usually fairly constant, but if the pipe is required to change direction from the vertical and is carried horizontally for some distance before reaching the receiving basin, an intermittent discharge may be noticed. This occasionally appears as though the water and air formed alternate strata in the discharge pipe. As, however, the receiving basin is usually constructed as near to the well as possible, the intermittent discharge does not prove detrimental to satisfactory operation. A battery of wells may be constructed when a large supply is desired in which event it is better to have independent air and discharge pipes for each well, each with a separate inlet to the receiving basin also.

If the well is drilled to a water-bearing strata and does not have to depend on seepage from a river or lake bottom there will be some little difference in the casing. If the water will rise high enough in the well a single casing may be all that is necessary, and otherwise the points at which the perforations are to be made must be determined by the depth at which water is found and the submergence necessary for proper operation.

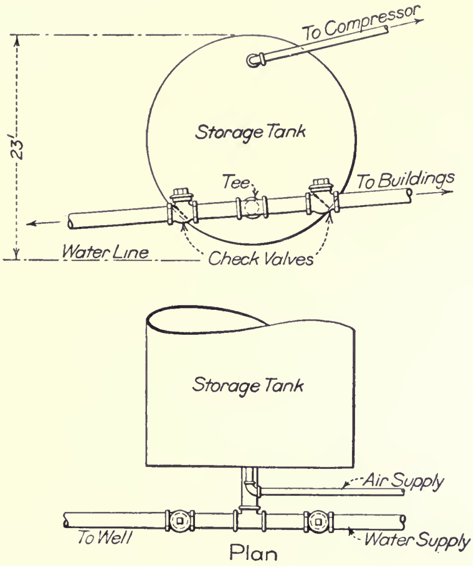


FIG. 66—COMBINED VACUUM AND PRESSURE WATER LIFT

Combined Vacuum and Pressure-Method of Raising Water.

Where water is to be raised from a brook, lake or spring, or from a shallow well located at some distance from the buildings to be supplied a convenient use may be made of a compressor so constructed as to act as a vacuum pump on occasion. The manner in which this may be done is illustrated in Fig. 66. Here a storage tank is located at a point near the source of supply and within 25 ft. of the water level. The pipe corresponding to the pump suction pipe is led from the well to the storage tank and connected to it through a tee and has in the line a check valve opening toward the tank as shown. The pipe which is to supply the building is connected to the other branch of the tee and to the top of the tank a pipe leading from the compressor is connected.

To fill the storage tank the pump is used as a vacuum pump, exhausting the air and consequently drawing water from the well to replace it. When a condition of vacuum exists in the tank the check on the supply pipe remains closed, while that on the suction pipe from the well opens. As soon as the tank is filled and the action of the pump is reversed so that it is compressing air, the lower check closes and that on the house supply pipe opens.

If preferred an air-storage tank may be used so that it will not be necessary to run the compressor steadily, or if electric power is available an automatic control of the machinery may be effected. The value of the system lies in its applicability to situations where it would be impossible to lift water to the location best suited for the pumping machinery, or where a suitable location for a large storage tank cannot be found within reasonable distance of the buildings it is to supply. Three-way cocks are used at the point of control so that the action of compressing or exhausting air may be conveniently controlled without stopping the machinery.

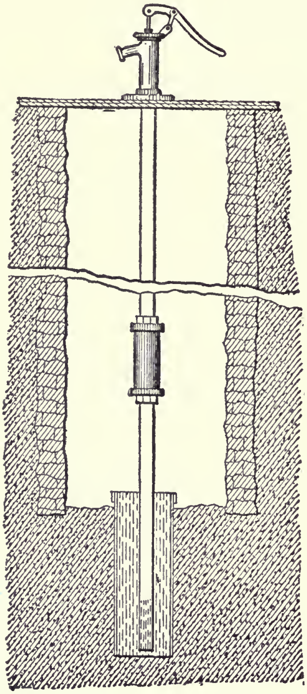


FIG. 67—A REINFORCED WELL

Reinforcing a Shallow Well.

In times of drought many wells either become dry or the water level falls so far that it is impracticable to use them. This, of course, is due to the gradual falling of the underground water level owing to the lack of rain. Wells that have been sunk in a wet season are more likely to prove deficient than those sunk in dry seasons as the ground-water level would be at its lowest in the latter case when the well was sunk and, therefore, in normal seasons the water would stand above the level at which it was when the well was dug.

Such wells, however, may be reinforced. That is, the depth may be increased and the water-bearing strata reached by the pipe when extended.

After a well curb has been put into place and the earth settled solidly around, it is a matter of no little difficulty to deepen the well by the old method of digging out and sinking an inside curb.

In wells having a substratum of gravel, sand, or even quicksand, the most treacherous of water holding material, much can be done toward obtaining a greater depth by materials and appliances that can be furnished by any tin or sheet-iron worker, or by a neighboring blacksmith.

A well which has been reinforced in the manner indicated is shown in Fig. 67. The reinforcement consists in driving to a depth of from four to six feet below the well bottom a slotted sheet-iron pipe such as is shown in Fig. 68. This may be made of galvanized sheet iron of No. 18 gauge with a band of the same metal about 2 in. wide riveted on each end. The length required should be found by driving into the bottom of the well an iron rod some ½ in. in diameter. This will tell if there are any rocks or boulders to be encountered in driving the sheet-iron tube. The tube may be from 8 to 12 in. in diameter according to the size of the well, the pump and the suction pipe.

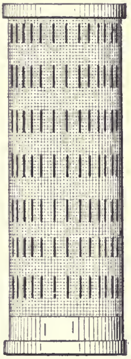


FIG. 68—DRIVING TUBE

The slots in the tube may be cut on a mandril with a sharp chisel. They should be no wider than is necessary to allow a slip of tin to pass through them. That is, the slots will not measure over 1/64 in. wide. They should be cut in rows as shown so that the strength of the tube will not be lessened materially.

The augur which is used to bore out the sand from the inside of the pipe may be made of the same iron as the pipe and from 1 to 2 in. in diameter. The cylinder should be made about 18 in. in length and the boring end should have a spiral lip as shown in Fig. 69. The bottom of the cylinder should be strongly soldered or riveted to the walls.

The operation of boring out the earth for the strainer tube can be conveniently accomplished by placing two ladders in the well. A board laid across two rungs will afford firm footing for the operator. The strainer tube should be placed in the position it will occupy in the well and pressed down into the sand as far as possible before the sand augur is used. Then the augur is applied and a charge drilled. When the cylinder is full of sand it should be passed out to the assistant and emptied and the operation repeated until the tube has been sunk far enough. When enough has been drilled the strainer tube should be hammered into position with a wooden mallet or a piece of board laid across it to receive the blows from an ordinary hammer. Finally, the remainder of the sand should be bored out with the augur so that the pump may be extended almost to the bottom of the pipe without drawing sand.

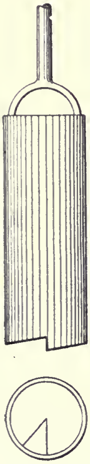


FIG. 69—A WELLBORING AUGUR

If the pipe is to be driven to a greater depth than 4 to 6 ft. a pipe of heavier calibre should be used. Ordinary galvanized-iron pipe of 6 in. diameter or more with holes drilled in it at frequent intervals may be used in place of the sheet-iron pipe. In this case it is necessary to cover the pipe with fine brass gauze. The gauze should be soldered at the seam and also in spots between the holes in the pipe to keep it in position when it is being driven into the earth. The appearance of the pipe when covered is shown in Fig. 70. In this way a reinforcement up to 20 ft. in depth may be made if only sand is to be drilled, and in large wells these pipes may be duplicated or a battery may be used if the supply pipe the suction pipe itself may be driven into the sand with a well point of the usual type attached to the lower end, as shown in Fig. 71. In this case also the supply may be increased by duplicating the suction-pipe extension and connecting them together above the level of the bottom of the well pit. As many as 4 pipes may be connected in this fashion when conditions are right.

Where there is uncertainty as to the character of the lower stratum, which may be clay, or have boulders that require to be displaced, it is better to make the reinforcement of a more substantial material, say of the ordinary galvanized iron pipe with screw joints; using a little more precaution in fastening the wire gauze strongly to the perforated pipe. For large strainer pipes, say of 6 to 10 in. in diameter, machine screws may be used to fasten the gauze to the pipe, and a spot of gauze around each screw head soldered to it; also a row of screws around the bottom to keep the gauze from slipping.

For large reinforcements to be made without boring out the sand, or where severe driving may be necessary, as through a clay stratum, a point or chisel may be made for the strainer, Fig. 70, by drawing or flattening a short piece of pipe and screwing into the lower coupling. The upper end of the completed pipe should have a screw cap for receiving the blows of a hardwood ram, which may be a stick of oak timber, handled by hand or slung in a rope over a pulley.

Where there is opportunity of using a lever or screw jack to press the pipe down, it makes the work much easier. The fulcrum may be a piece of timber placed across the well and loaded with stone.

In wells that bottom on rock, a reinforcement may be made by drilling a 3 or 4-in. hole in the rock to the desired depth, and placing the pump suction and strainer within and reaching to the bottom of the drilled hole, as shown in Fig. 72. In this way not only the whole available depth of the original well may be utilized, but often a large increase of flow may be had from the fissures in the lower rock stratum.

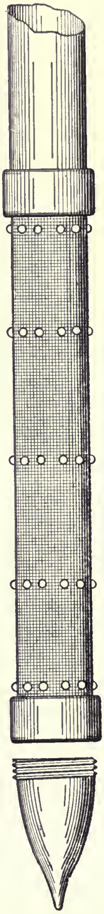


FIG. 70—FASTENING GAUZE AND POINT TO LARGE STRAINER PIPE

Cooling Drinking Water in Wells.

Where conditions are right the water in a well, even if not of very good quality may be used to advantage in cooling water brought from other sources. Even in long-continued hot weather the temperature of the ground water seldom rises above 45 degrees, and if a water supply is taken from a lake or reservoir the water may be cooled to an appreciable extent by passing it through a cooler suspended in a well, whether disused or otherwise. In Fig. 73 is shown a method of fitting a cooling tank to secure a large area on which the cool well water will act.

If the pressure in the system is light it must be kept in mind that provision for the escape of air must be made, and in consequence the grade to the well cooler from the reservoir, storage tank or other source of supply should be constant as far as possible. An alternative method is shown in Fig. 74, where the tank is placed in a vertical position and the connections are made in such a fashion that the air collecting in the tank will pass out through the supply pipes to the building. Thus it may be drawn off each time water is drawn from the pipes. A coil of pipe may be used in place of the cooling tank, but the latter probably is more satisfactory and will not become stopped so quickly.

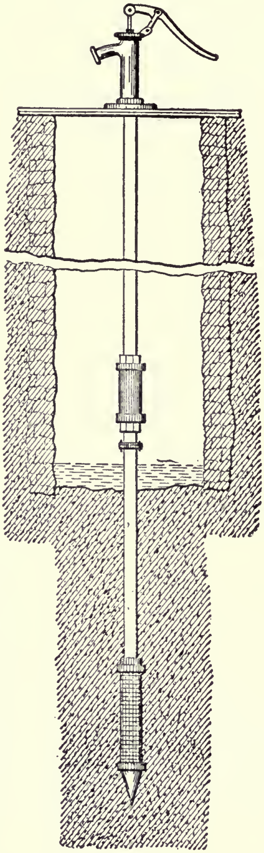


FIG. 71—DRIVE WELL POINT CONNECTED TO PUMP SUCTION

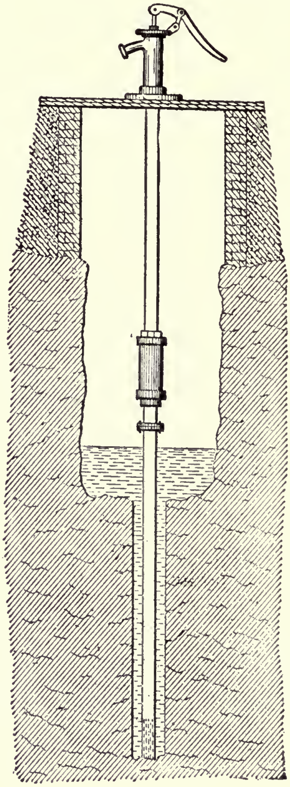


FIG. 72—REINFORCING WELL DRILLED IN ROCK

Sand Traps for Pump Pipes.

Where water is to be pumped from a brook or lake or from a driven well there is always some chance of sand being brought up and lodging in the valves and barrel of the pump. While the sand may be to some extent kept back by a strainer at the inlet or at the well point, some of the finer particles find their way through, and unless some means of stopping the sand from entering the working parts of the pump is found there will be trouble from leaky valves.

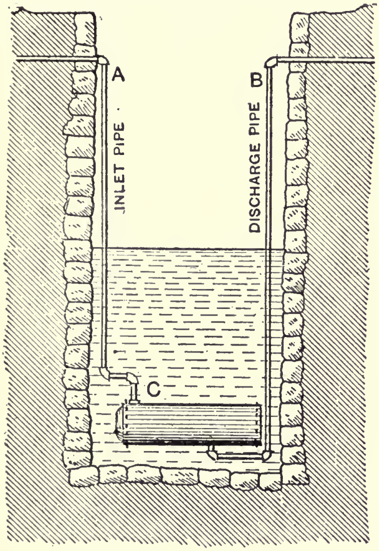


FIG. 73—WELL COOLER PLACED HORIZONTALLY

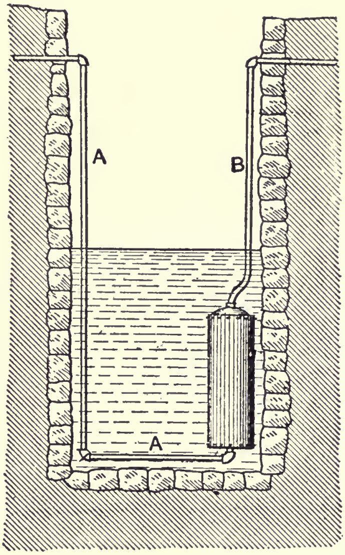


FIG. 74—WELL COOLER PLACED VERTICALLY

A simple sand trap which may be made from ordinary pipe fittings is shown in Fig. 75. This is a conical screen made from 50 mesh-brass wire cloth and measures about 3 in. from base to tip. It is soldered into a brass nipple inserted in the pump cylinder and a piece of pipe about 12 in. long is screwed into a tee beneath it. The suction pipe is connected to the branch of the tee and a cap finishes the short pipe. Thus the sand as it is drawn up to the working valves comes in contact with the wire cone and drops back into the short piece of pipe from which it may be removed from time to time.

Vacuum Chamber for Deep Well Pumps.

Occasionally a pump will work hard when the valve chamber is placed at a considerable depth and some relief will be experienced if a vacuum chamber is attached to the suction pipe as shown in Fig. 76. The chamber may be constructed of ordinary pipe fittings. All that is necessary is to insert a tee close to the working cylinder and use a reducing coupling and a piece of 4-in. pipe with a cap for the vacuum chamber. The joints must be perfectly tight and it is also advisable to use a foot valve on the suction pipe if the well is a deep one.

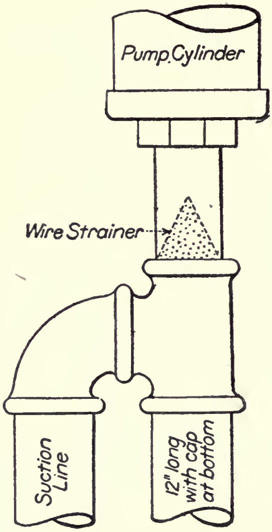


FIG. 75—SIMPLE SAND TRAP FOR PUMPS

A Simple Well Driving Appliance.

A simple arrangement for driving pipe wells without damage to the pipe and with an increase in speed is shown in Fig. 77. Its superiority over the hammer is that it never fails to strike a square blow, and it drives the pipe straight. It can be used with a derrick, as shown in the picture herewith, or simply by hand.

The principal feature is the driver, which also acts as a guide. This consists of a piece of wrought iron pipe, H, large enough to move readily over the pipe to be driven. A piece of 2-in. pipe is best adapted for all ordinary work. The bottom end of the guide is left open and a malleable iron reducer, *E,* is screwed on the top end. The other end of the reducer is tapped to receive a piece of 1¼-in. pipe of any length, to suit the work in hand, as the work progresses. The further down into the well the pipe is driven, the longer, of course, the piece of light pipe must be. At the top end of the 1¼-in. pipe a coupling, *C,* is placed, into which a short piece of pipe is screwed, one end being flattened, to have a hole drilled through it, to receive the clevis and bolt *B.* The clevis is only necessary when the driver is used in connection with a derrick made of shear poles. Then a pulley block, *A,* is fastened at the top of the shear poles and a rope, *K*, is run through it and tied to the clevis, so that the driver can be raised and lowered by means of the pulley.

An important feature of the driver, however, is a piece of hickory wood, *F*, about 6 in. long, made to fit snugly on the inside of the 2-in. guide pipe. This wood is put in the end of the guide against the reducing coupling, and it is through the medium of this wooden block that the blow is delivered to the drive cap *G* on the pipe *I*. When a good piece of wood has been selected and is properly fitted into the pipe, it will do the work for a number of years, not needing to be renewed.

Owing to the weight in the 2-in. guide pipe and the 1¼-in. pipe used to operate it, it is only necessary to lift the driver a few feet and then let it drop to deliver squarely, and in direct line, a powerful driving blow. The fact that the 2-in. pipe slides over the pipe to be driven keeps it moving in the proper direction, whether it be operated by means of a pulley from poles or is lifted by one or more men and then allowed to drop.

If a 1½-in. well pipe is to be driven, a 1½ x 1¼-in. reducer may be put on a 1½-in. pipe in place of the drive cap; then a piece of 1¼-in. pipe can be screwed into the reducer and the drive cap screwed to the upper end of the 1¼-in. pipe, to receive the blow. When the 1½-in. pipe has been driven down near the ground ready to receive the pump cylinder, the 1¼-in. pipe with reducing fitting can be unscrewed from the 1½-in. pipe and the pump cylinder attached.

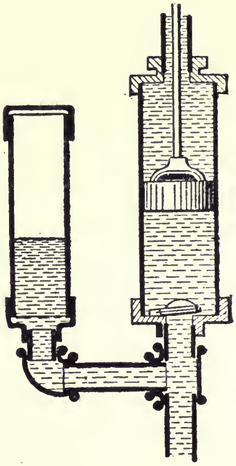


FIG. 76—VACUUM CHAMBER FOR DEEP WELL PUMP

The coupling at *C* enables the length of the driver to be adapted to the depth of the well in which the work must be done. If a man is provided with several sections of pipe, he can adjust the length of the driver so as to drive the well from the surface, either out of doors or in a house. The apparatus can be readily arranged so that one man can work it alone, or three or four men can use it by hand.

Raising Water by Siphonage.

It is occasionally necessary, though never advisable, to use siphonage to bring water from the source of supply to the buildings to be supplied. This might be necessary through the topography of the ground around the buildings. For instance, a well might have to be sunk at an elevation higher than that of the buildings, or there might be some rising ground intervening between the source of supply and the buildings. In such an event it is customary to carry the supply pipe to the building exactly as if the supply were by gravity, but instead of connecting to the bottom of the well the pipe is turned down into it at the lowest convenient level. At the highest point means for priming the pipe to start siphonic action are provided. This may take the form of a stopcock inserted in the pipe and with a funnel as shown in Fig. 78 into which water may be poured so that the supply pipe to the house may be filled. On the opening of a faucet at the house after the pipe has been filled the water will fall in the supply pipe, exhausting the air in the short leg of the siphon which is under water in the well, and the consequence is that water will rise in it and flow continuously to the house so long as air does not

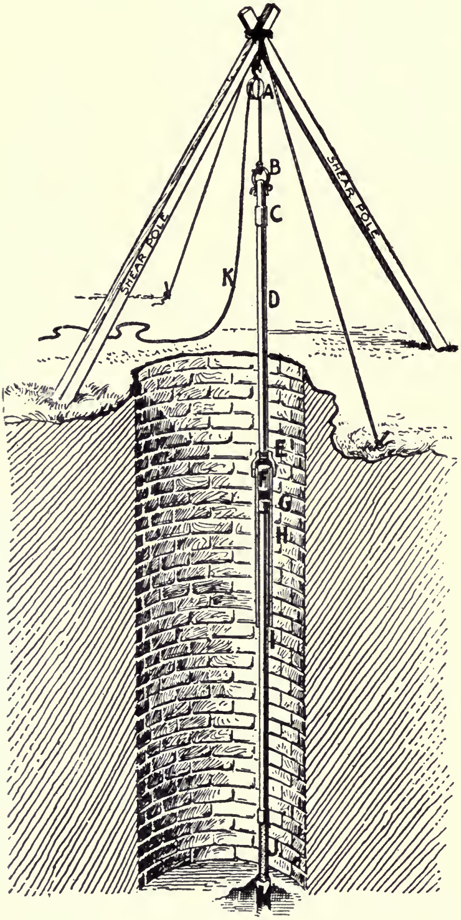


FIG. 77—A WELL DRIVING OUTFIT

find admittance to the pipe. It time, however, the air liberated from the water will lodge at the high point, fill the air vessel and eventually break the siphonic action. When this occurs it is necessary to open the cock at the high point and recharge the pipe with water as before.

There is a limit to the height to which water can be raised by siphonic action. As the action is entirely due to the pressure of the atmosphere a column of water with a static head exceeding the pressure of the atmosphere, namely, 14.7 lb. cannot be raised. The limit in theory should be about 34 ft., but, in fact, a column exceeding 25 ft. in height cannot be raised with satisfaction as the friction of the pipe has also to be overcome. No matter how much fall on the "long leg" is available, this height cannot be exceeded.

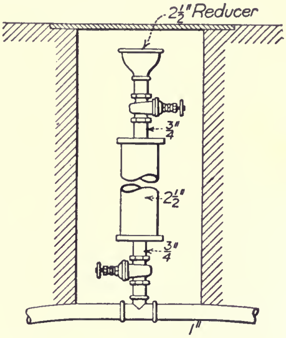


FIG. 78—ARRANGEMENT ON SIPHON TO FACILITATE STARTING AND TO COLLECT AIR

In arranging for a siphon system the height to which the water must rise above the lowest point of the long leg of the siphon must be deducted, as the effective height will be at that point, and to secure satisfactory operation this should always be a few feet lower than the highest point of the siphon. Otherwise there will be continual trouble from the breakage of the siphonic action. The diagram in Fig. 79 illustrates the point.

If it is not convenient to use a stopcock and filling attachment at the high point, water may be pumped back from the fixtures at the house end to start the siphon again. The only thing that has to be looked for is that the faucets in the house should be closed until the pipe is full of water and all air expelled. Then on the removal of the pump and the opening of the faucets again water should flow immediately.

The successful operation of siphons having long horizontal stretches and little fall or head is very rare for the reason that air which is contained in all water exposed to the atmosphere will accumulate in the siphon and stop its operation. Just where it will be found can best be determined by making a siphon of glass tube.

Where there is a long horizontal stretch in the upper part of the siphon, the element of friction is a factor, which will retard the flow and allow the air to resist the effort of the water to carry it to the outlet. One remedy that can be applied when the fall is nearly all at the discharge end is shown by Fig. 80; that is, reduce the size of the pipe at what may be called the critical point, thereby accelerating the flow. This will prevent the air from rising, and the siphon will work continuously.

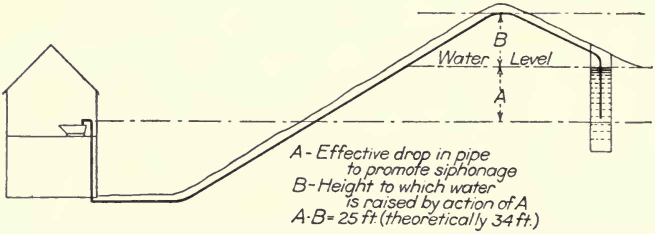

B
Water Level
A
A - Effective drop in pipe to promote siphonage
B-Height to which water is raised by action of A
A·B= 25 ft. (theoretically 34 ft.)

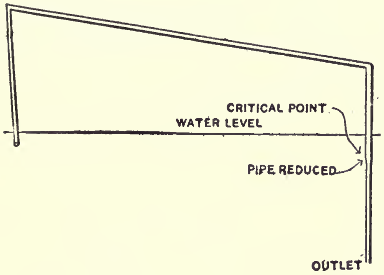
FIG. 79—DIAGRAM ILLUSTRATING ACTION OF SIPHONAGE

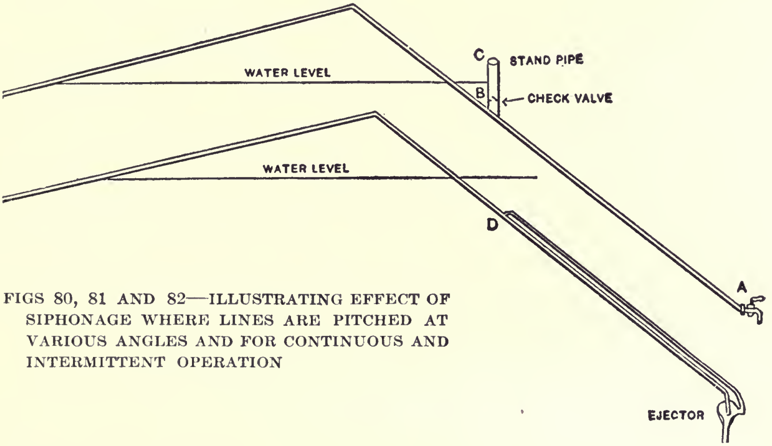
We may now consider the case where the siphon has a long, gradual incline upward from the water to the highest point and a similar downward incline to the outlet. This is illustrated in Fig. 81. In this case it is intended to draw water at intervals, and the cock A should be opened full. B is a small check valve, C is a comparatively large open stand pipe. If there is a little air in the siphon it will extend from the top downward, say to the stand pipe. Now when cock is opened the air in the slanting pipe will be drawn down to the stand pipe or further. The cock is now closed so that the air can rise. Some or all of it will find its way into the stand pipe and pass upward through the check valve, while the stand pipe, being higher than the water at the intake, will not overflow.

Fig. 82 is a case similar to Fig. 81, only intended to run all the time. Here the siphon is tapped with a small air pipe at D, run parallel to the outlet and connected with an ejector. The column of water from the water level to the ejector in this case is the means whereby a vacuum is created sufficient to prevent air from accumulating in the siphon. In other words, the rapid flow of water through the ejector will create a suction or draft in the small pipe that will continuously free the larger one from any air that seeks to collect in it. A combination of Figs. 81 and 82 may be made by connecting the air pipe to a closed stand pipe and putting a gate valve above the ejector.

Intakes to Pump and Gravity Supply Lines.

Where water is taken from a brook or from a lake it is customary to provide some means of straining the water, especially when the source of supply is liable to become turbid in times of flood. In a lake, if the system is an important one, it is customary to build a crib or intake out in the lake at a point below the low water mark. In small systems this is seldom necessary and the intake pipe is simply extended into the lake far enough to ensure that there will be no risk of pollution and that the supply will be available even when a dry season has lowered the water level much below the normal.





FIGS 80, 81 AND 82—ILLUSTRATING EFFECT OF SIPHONAGE WHERE LINES ARE PITCHED AT VARIOUS ANGLES AND FOR CONTINUOUS AND INTERMITTENT OPERATION

Alternatively a pit may be sunk at the edge of the lake and a pipe led into it, or the water allowed to rise in it as from a spring. Such a pit may be made to act as a filter if the water is caused to pass through a compartment filled with sand and gravel. In any case a strainer must be used at the intake end of the pipe submerged in the water.

Where the intake is from a brook it is well to provide against mud, leaves and grass entering the pipe. If a dam is formed on the brook at the point where the intake pipe enters it, a wall which will deflect the stream so that mud will not be built up against the pipe should be constructed or a large strainer with one side blank should be used. These arrangements are illustrated in Figs. 83 and 84.

Alternatively a pit may be constructed beside the brook and the wall in contact with the water built without mortar as shown in Fig. 85. Thus the water filters through the brick wall, and mud and grass carried by the stream cannot find its way into the supply line.

If a pipe line is laid into a swiftly flowing stream it should be anchored securely by driving piles on the lower side. If this is not done an undue strain is put on the line when floods carry limbs of trees and quantities of silt against it.

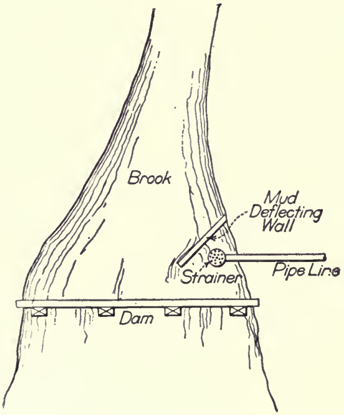


FIG. 83—DEFLECTING WALL AND DAM AT INTAKE FROM BROOK

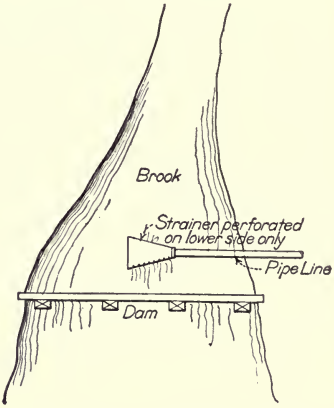


FIG. 84—BLANK SIDED STRAINER TO PREVENT SILTING AT INLET

A dam of the proportions generally necessary for water supply work to country residences may be built of timbers laid behind piles driven into the bed of the brook, or if the brook is a wide one a double row of piles may be driven into the bed across the entire width of the brook. A clay wall may then be constructed between the rows of piles and a bank of masonry, concrete or wood then built on either side of them. The lower side is generally pitched at a lower angle than the upper so that the water will flow over the dam easily in time of flood and also so that no interference will be made to the upward passage of trout should the brook contain them.

Sheet metal or concrete piles may be used with satisfaction for this kind of work. A longer dam can often be made and a larger body of water be retained in dry seasons by building the structure diagonally across the brook. When this is done the supply should be protected against the entrance of sand and mud if it is taken from the lower part of the dam and a pit built as described and illustrated in Fig. 85 is advisable in such a case.

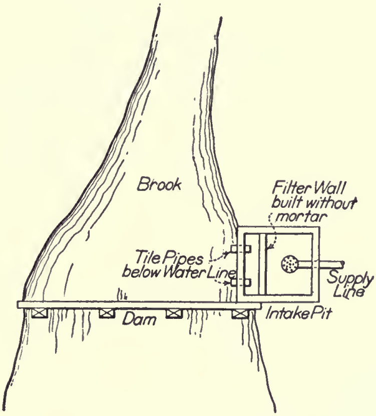


FIG. 85—CATCH PIT FORMED AT DAM TO PREVENT INTAKE OF MUD

CHAPTER X.

DISTRIBUTION OF WATER SUPPLY TO BUILDINGS.

The materials used for main distributing pipes from the tank, spring or pump to the buildings to be supplied are cast iron, galvanized wrought iron or steel and lead. The first is generally used when the system is a large one, the second is probably the most commonly used and the third is used only on small supply systems.

Cast-iron pipes for water supply are made in 12-ft. lengths and in sizes from 3 in. in diameter upwards. They are much heavier than those used for drainage work and the bells are deeper. Bends, tees and other fittings are correspondingly heavy. It is seldom that cast-iron pipes are required for country water-supply systems excepting for connections to reservoirs where its use is often preferable. Another style of pipe is known as Universal pipe and has the joints made by means of a patented flange which admits of a tight joint being made even when the parts are considerably out of alignment. For heavy pressures and where the ditch is crooked owing to a rocky formation of the ground this pipe is very convenient.

The standard weight galvanized water-supply pipe gives satisfactory service under all normal conditions and is preferred owing to its ease of handling and adaptability. In all sizes up to about 4 in. in diameter this material is commonly used. No special style of fittings are required for underground distribution. Iron body valves may be used with economy and efficiency in the larger sizes and flange joints may be more convenient than couplings under some circumstances but otherwise the fittings are the same as those used in interior construction work.

The pipe may be had in the extra heavy weight if the soil or water conditions are likely to cause rapid corrosion.

Lead pipe is used in the standard weights according to the pressure it has to withstand. What is known as "spring" pipe is commonly used for small low pressure water supply systems but probably it is more economical to use a heavier pipe even when the pressure is low. In the smaller sizes B pipe is light enough to give satisfactory service and A is preferable. In the larger sizes, that is 1-in. diameter or over, A should be the lightest weight used and a heavier grade should be used if possible. Otherwise the bore is liable to become flattened through the settlement of stones and earth over the pipe or even the growth of trees near the track.

At points on a long line of water-supply pipe leading from a catch well or reservoir to a building on a lower level there are generally some high points at which air might collect and if the pressure is low this forms an obstruction to the flow. At such points air cocks should be provided with means of access in the form of cast-iron or wooden covers placed over a brick pit built around the air cock.

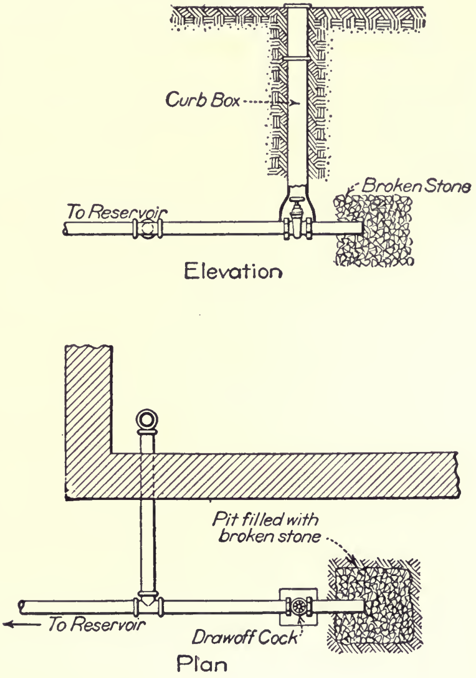


FIG. 86—PLAN AND ELEVATION OF WATER CONNECTIONS AT LOWEST POINT OF LINE FROM SPRING OR RESERVOIR

At the lowest point of the distributing system there should be a draw-off cock by which the entire line may be drained or scoured at least. If the line runs directly into the building at the lowest point there may be some risk of chokage should there be any sediment carried by the water or should there be any foreign matter from the source of supply that has found entrance to the system. If the line is continued beyond the building line a few feet and the connection made by means of a tee as shown in Fig. 86 the sediment is more likely to be carried into the end of the line and removed when the sludge cock is opened. This method of making the house connection should be used wherever it is necessary to drain the system in the winter season as is common in summer residence work.

Another plan is to carry the pipe directly into a header placed inside of the building and in which a sediment draw-off cock is placed. The header is intended to give an equable flow to each of several branch lines connected with it and is generally placed at a point immediately within the building.

Sharp bends should be avoided on distributing lines wherever possible. The track should be as straight as it is possible to make it and when it is necessary to change direction it should be done by bending the pipe rather than by using fittings. If there are sudden changes in grade the same applies. If it is necessary to make a bend it should be made so that the pipe will lie in the ditch without strain on any of the joints. It will probably lead to a breakage if the pipe is forced into the ditch to avoid making a bend and if the position is such that a bend cannot be made satisfactorily, a better job will be made by cutting a crooked thread on a short piece of pipe so that the necessary change in direction may be gained.

Flange joints with soft gaskets are undesirable in underground water-supply work. If a flange joint must be used the type with ground seats should be selected. The same applies to unions although lead washers may be used on the smaller sizes with success, but a metal-to-metal ground seated union is to be preferred.

Branch connections should be made by means of a tee set at an angle of 45 degrees to the run of the pipe if possible. This is desirable on the score of safety from breakage at the connection as well as less danger of sediment being washed into branch connections when it is necessary to scour the main pipe.

When valves are placed at the highest point of a distributing system, for instance outside of the walls of an underground storage tank, an air pipe with a valve should also be provided, or a pet cock should be tapped into the pipe if it is accessible. If this is not done the closing of the valve will not allow the pipe to drain and it is necessary to admit air at the highest point before all of the water will fall to the lowest point and so through the sediment or draw-off cock.

In filling the pipe ditches after the pipes are laid it should be made sure that earth free from large stones is placed over the pipe first. If the filling is loose there may be spots where the frost will penetrate easily and even when the pipe is laid at a depth sufficient to protect it in ordinary circumstances trouble may be experienced at one or two points where the filling has been carelessly done and the whole system be tied up.

In laying wrought iron or steel pipe for water supplies, the lead used should be put on the male thread. If the inside of couplings or other fittings is painted with a thick coat a considerable part of it will find its way into the bore of the pipe and it may be several weeks before all of it can be washed out. A thin lubricating coat is all that is necessary if good threads are provided, even when the pressure under which the system will operate is heavy.

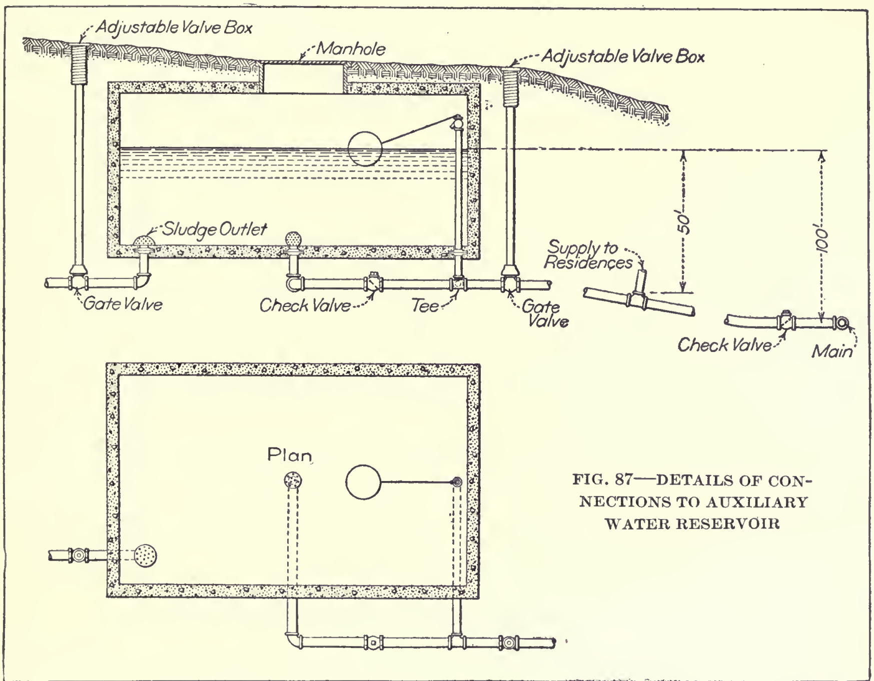


FIG. 87—DETAILS OF CONNECTIONS TO AUXILIARY WATER RESERVOIR

Providing a Compensating Tank for a Group of Buildings Supplied from a Spring.

When a group of buildings is supplied with water by a gravity system and one or more of the group is situated at a high elevation there is a possibility that in periods of drought the higher buildings will suffer from a shortage of water at certain times of the day. This condition will not be evident if the main reservoir from which the supply is taken is large and at a high enough elevation to compensate for any excess in draught in the lower buildings at such times as the water is entering the reservoir in less than normal quantities.

It is fairly common, however, to find the supply taken from a spring at an elevation very little above that of the highest building and should the flow decrease to any considerable extent the supply to the higher buildings will only be good in the night time when the demand in all of the buildings has fallen to the minimum. In this event a compensating reservoir in which water may be stored in the night time for the use of the higher buildings may be constructed. Fig. 87 shows how the arrangement of valves and connections may be made.

It is not necessary that an underground tank be used, although this ensures a supply of water always cool and pleasant even in the hottest weather. A steel or cypress tank may be used with equal advantage.

The illustration in Fig. 87 shows a concrete tank with a flat roof of reinforced concrete in which a manhole is placed. The tank is situated approximately 50 ft. above the level of the buildings to be supplied while the main supply pipe from the reservoir supplying all of the water is 50 ft. below this connection. The spring and main reservoir are of course at a level still higher than the compensating reservoir, but when the greatest amount of water is required the pressure in the system is insufficient to raise water to the highest buildings.

Therefore a connection is made to the pipe and carried up to the new tank with a check valve placed near to the connection as shown. Another check valve is placed on the pipe before the connection to the tank is made, but in this case the check swings in the opposite direction. The reason for this is that a ballcock is placed on a branch supply carried into the tank and continued above the water line. When the pressure in the main pipe is at its highest in the night time water rises freely through this line and the compensating tank is filled. As soon as the desired amount of water is delivered the ball valve closes and prevents waste.

The upper check valve prevents water entering through the lower connection and the lower one prevents its falling back into the main line when the draught begins again at the lower buildings. The result is that a sufficient amount of water is stored each night to cover the demand of the next day, and so any shortage in the supply is made less evident. If, of course, the flow from the spring falls off so much that the actual amount available is less than that consumed each day by all of the buildings in the group such a compensating tank will be of little use, but it is seldom that such conditions are encountered, though common to find the pressure temporarily reduced so much that a sufficient supply is not to be had.

The tank is also provided with a sludge cock so that it may be cleaned at intervals and a gate valve is placed on the supply line outside of the walls, or inside if preferred, so that the supply may be closed should repairs be necessary. Both valves are provided with adjustable "curb boxes" with square headed iron keys. If it is desired to place the valve inside the tank the pipe should enter through the side walls.

To make a sound joint with the concrete it is advisable to fit a flange on the pipe at such a position that it will come at the center of the wall. Flanges made of cast lead in two parts afford satisfactory service in this respect, and it is seldom that a leak will be experienced at this part when such are properly fitted. Copper strainers should be placed both on the supply and sludge outlets. These should be of generous size, so that no interference with the flow will be made. A ball valve of the compensating type should be used to prevent water hammer being set up in the supply pipe and, if possible, the supply pipe from the main to the tank should be run without depressions which might cause air-locking.

Types of Storage Tanks.

Storage tanks for water supply purposes may be divided into three classes—underground gravity tanks, overhead gravity tanks and underground or basement pressure tanks. The first class is commonly constructed of concrete or brick and almost invariably placed near the source of supply. The second may be of steel or wood, generally cypress, and placed on a tower erected in any convenient location, or it may be of wood lined with metal or built of metal plates and placed in the upper story of the building to be supplied. The third class is better known as the pneumatic water supply tank and is made of steel plates. As indicated it may be placed underground wherever convenience dictates or in the basement or power house if desired.

The reservoir for a country residence, even when it is of a pretentious nature, is often merely a collecting pit built around one or more springs, and may either form part of a gravity system of supply or of one requiring pumping machinery to raise the water to the desired elevation. In the latter case it may be taken for granted that either an overhead tank or a pneumatic one will be required in addition. If the tank is merely a catchpit around a spring and the spring is at an elevation sufficient to supply the house by gravity, then the tank is a reservoir only so long as the flow from the spring continues in excess of the amount required at the house. In periods of great drought the ground water level may fall to a considerable amount and in consequence the flow of the spring will be less. The water will rise to a lower level and the amount available for immediate use in the catchpit will be less. If such conditions are to be obviated it is necessary to build a separate tank which will be filled from the catchpit. Then, even if the ground water level falls, the height of water in the reservoir will remain constant so long as the flow of the spring is of sufficient volume to maintain a supply equal to the consumption.

It is common to provide a tank which will contain at least three days' supply for the establishment. If water is used at all freely there should be an allowance made for each member of the household of at least 40 gallons a day. The consumption in many cities is four times this amount, but this is a fair average allowance to cover all domestic purposes. Where horses and cattle have to be provided for an allowance of 10 gallons for each horse or cow, about 3 gallons for each hog, and 2 gallons for each sheep should be made. For lawn sprinkling the amount required may be ascertained by estimating that an ordinary hose nozzle will pass about 5 gallons per minute. For washing carriages and horses allow about 15 gallons for the former and 4 gallons for the latter. From these figures the approximate consumption of water may be obtained and the proportions of the tank estimated.

If it is decided to construct a concrete reservoir around the spring, judgment must be exercised in making the excavation. In some conditions, especially where the spring issues from till or sandy soil over hardpan, it is possible to "lose" the spring through careless excavation affording it a means of easier egress. The foundations, however, must be carried down far enough to ensure that the water will not seep through below the walls, but will rise to a sufficient height in the reservoir to provide an adequate supply.

Clean, sharp sand and broken stone or screened gravel should be used. The size of the reservoir will determine the thickness of the walls, but these will probably average about 8 in. in thickness for reservoirs up to about 2500 gallons capacity. A good concrete may be made by mixing 1 part of cement, 2 parts of sand and 5 parts of gravel or broken stone. After the forms are removed the inside of the tank should be plastered with a mixture of 1 part of cement and 2 parts of sand, or it may be brushed over with grout of about the same strength.

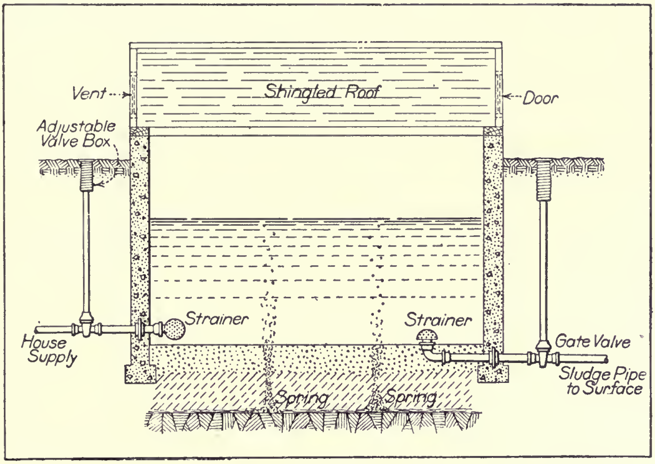


FIG. 88—SECTION THROUGH UNDERGROUND RESERVOIR CONSTRUCTED OVER SPRING SHOWING METHOD OF CONNECTING SUPPLY AND SLUDGE PIPES

In order to allow the water from the spring to escape while the walls are being built an opening may be left at the place where the sludge pipe will leave the reservoir. When the walls have been completed and plastered, clay should be banked up so as to prevent the water from coming forward to the opening and the pipe should be inserted and allowed to project into the reservoir so that the end will be within the bank formed by the clay. Then if the valve is left open the water will have free outlet while the hole is being filled with concrete. Care must be taken to pack the material firmly into the opening, and after the concrete has become set it should be carefully plastered over and finished around the pipe. If a lead flange is bolted on the pipe so that it will be half way in the wall when the pipe is in its position there will be less chance of the concrete shrinking away from the pipe and allowing a stream of water to leak by to the outside. The supply pipe may be placed in the walls while they are being constructed. It should be placed at about 6 in. above the floor level and should have a flange bolted on it also. The details of a tank and connections are shown in Figs. 88 and 89.

A brick tank will cost a little more than one built of concrete and there will be no material advantage over concrete. When brick is used the mortar should be composed of sharp sand and Portland cement in the proportion of 4 to 1, and the inside of the tank should be carefully plastered with mortar of a strength of 2 to 1. The same care must be taken where the pipes pass through the walls.

Overhead tanks may be constructed of steel or of wood, the latter having the greater vogue. Steel tanks are built both rectangular and circular in shape, according to the requirements to be met. When placed on towers exposed to the weather they are almost invariably covered by either a wood or metal roof. When a wooden cover is used it is well to make it with a pitch so that water or snow will not remain on it. An instance of the folly of using a flat covering on a tank is on record where snow fell to a considerable depth and then melted. The water had been drained from the tank as it was used in connection with the supply to a summer cottage. There had been severely cold weather before the snow fell and frost had penetrated the ground to a considerable depth. When the snow melted on the roof it leaked into the tank and ran down the outlet pipe to the distributing system. In the underground pipes, where the earth was frozen hard the water became frozen and split several lengths. These were on a hillside with a considerable pitch and must have been quite empty when the water trickled down from the tank. While the same results might never be experienced again, the safeguard afforded by a pitched roof is obvious.

Wooden tanks of the cylindrical variety are generally built of cypress. They come knocked down and should be set up and filled with water as soon after delivery as possible. In erecting a tank a solid foundation is provided upon which the bottom may rest so as to keep the weight off the chimes for the most part. The bottom having been put together, the staves are set up and the hoops put on. These are spaced out to the correct distance and then each is drawn up a little so that the staves will be drawn together at the top and bottom at about the same rate. While minor leaks may be in evidence at first, these soon disappear as the wood swells in contact with the water so that it is not advisable to draw the hoops to the limit at first.

Where the pipe passes through the bottom of the tank a good connection is necessary. One method of making a substantial joint is illustrated in Fig. 90. This calls for the use of a plate outside and inside the tank. The pipe is threaded and allowed to pass through the outside plate for a sufficient distance to have the end project through the bottom of the tank and a plate on the inside. Between the plate and the bottom of the tank is placed a gasket made of hemp and soaked with red lead in oil. This fits the pipe tightly and when the plate is drawn down upon it by the action of the locknut the gasket expands and makes a perfectly secure joint.

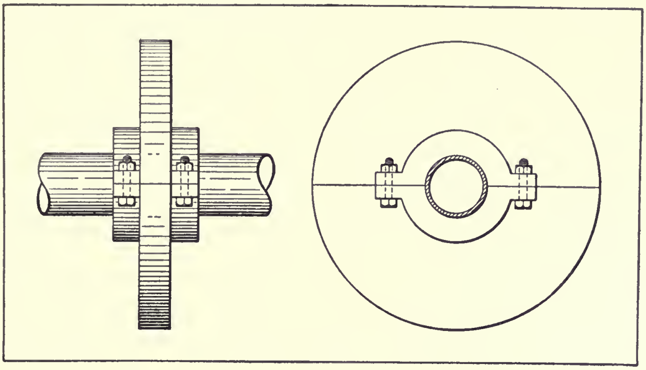


FIG. 89—DETAIL OF FLANGE BOLTED ON PIPES IN WALLS TO MAKE SECURE CONNECTION

If the tank is to be used at all seasons it will be necessary to make some provision for protection of the pipes from frost. This is affected by wrapping them first in a double coating of hair felt or one of the patented brands of pipe covering. Then a box is built around it and a second box around that again, leaving an air space of about 1½ in. between the two. An access door should be left to operate any valve on the line, but this may be obviated also if the valves are placed underground. Nothing is gained by running a separate discharge pipe to the tank from a pump as a rule. If a check valve is placed in the right location the supply to and from the tank may be made through one pipe with satisfaction, saving trouble in fitting and in protecting it from frost.

If the supply to the tank is not from a pump, but comes from a spring or other source at a higher elevation, and a ball valve is necessary to control the supply, it may be preferable to use separate pipes for the supply and outlet, although checks can be placed so as to use one pipe only. If it is desired to have a pipe pass up through the bottom of the tank to above the water line the connection may be made as shown in Fig. 91 with satisfaction. This shows a special flange fitting with a hub through which either a cast- or wrought-iron pipe may be passed. The joint is made water tight by calking with oakum and molten lead. A balanced float valve is generally used in tanks of this type so that water hammer will not be set up by the action of a valve closing quickly under a heavy pressure. As steel tanks are made of relatively thin plates riveted together, spuds are generally used where connections are to be made to them. If a pipe is required to pass up to a point above the water level a fitting such as that shown in Fig. 91 can be used to advantage, but it will have to be made to rivet to the bottom rather than be drawn together with plates as in a wooden tank.

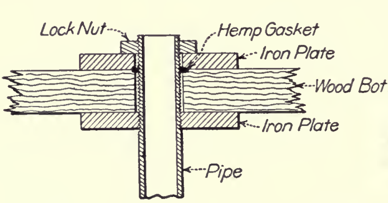


FIG. 90—METHOD OF CONNECTING OUTLET TO WOODEN TANK

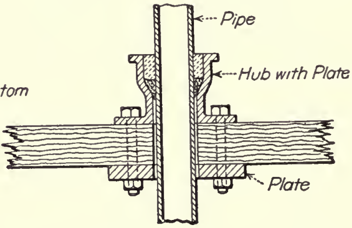


FIG. 91—CONNECTION OF PIPE PASSING UP THROUGH WOODEN TANK

What are commonly known as house tanks are made of a rectangular shape and are lined with copper or lead. The former metal is most popular, as it is lighter and easier to handle. Tanks of 3 ft. in height or over, if the length exceeds 4 ft., should be well braced to prevent strain on the seams of the lining. The construction shown in Fig. 92 is recommended, as the strain is equalized throughout and the tie rods obviate the use of heavy planking in the tank. The connections to a copper-lined tank may be made with iron or brass pipe and the use of lock nuts and flanges if desired, but a more flexible connection is secured if a short piece of lead pipe is used between the rigid iron or brass pipe and the tank.

Lead pipe may be connected to the copper lining by a wiped joint and a brass solder nipple may be wiped to the other end to connect with the pipe. An overflow pipe may be connected into the side of the tank in the same manner, and if it is desired to provide a means for washing out the tank a sludge pipe may be wiped into the bottom. To secure the best results the copper lining should be turned up and the wood countersunk for a distance of about 1¼ in. around the hole through which the pipe will pass. Then the copper may be beaten down into the depression and the lead pipe brought up flush with the inside and wiped flat.

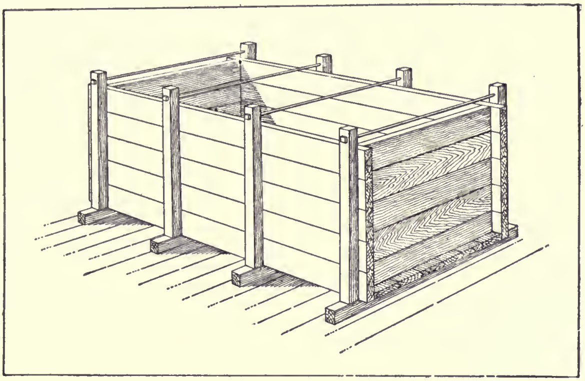


FIG. 92—A GOOD METHOD OF WOODEN STORAGE TANK CONSTRUCTION

A valve can be placed on the pipe outside the tank. An alternative is to provide a ground socket which is wiped into the tank along with the sludge pipe, as described, and to the spigot end of the fitting a stand pipe is soldered. This provides a combination overflow and sludge pipe. The arrangement is shown in Fig. 93.

Overhead Tank Supplied by Hand Pumps.

A simple water-supply system is shown in Fig. 94. Here a copper-lined wooden tank is placed in the attic to supply the plumbing fixtures and is supplied by two horizontal hand pumps coupled to a common suction pipe. The only advantage in providing two pumps is that the tank may be filled more quickly. In this case it is necessary to provide a suction pipe of greater capacity than would be used for one pump only, and a pipe one size larger would be required.

Checks are fitted below and above the pumps so that the operation of one only will have no effect on the other, or when both are being operated water will not be drawn by one pump at the expense of the other.

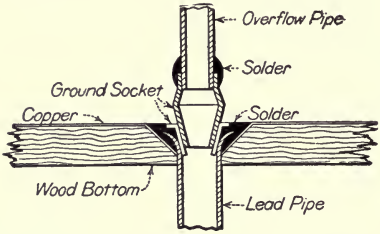


FIG. 93—COMBINATION OVERFLOW AND WASHOUT CONNECTION TO WOODEN TANKS

An alternative method is to use an underground tank as indicated in Fig. 95. As arranged the system is intended to be filled by one hand pump, compressing the air in the storage tank until the desired pressure is raised. As the air is absorbed by the water and the supply decreases in consequence, the air pump is operated and the compression is thereby increased and the available supply of water at the fixtures brought to a higher point again.

CHAPTER XI.

WATER SUPPLY BY AIR-PRESSURE, FIRE PROTECTION, SPRINKLERS.

Pneumatic water-supply systems are of two general types, those in which water is raised direct from a well or other source of supply by means of air pressure acting in a submerged chamber or pump and those in which water is pumped into a storage tank and in which the air compression attending the pumping into the tank is depended upon to force the water to the required level. Therefore the descriptive nomenclature of storage and non-storage types is sufficient to indicate to which type a system belongs.

In the first type the pump used to elevate the water consists generally of two submerged cylinders with an arrangement of inlet and outlet valves operated automatically. At the commencement of pumping operations the inlet valve in one of the submerged cylinders allows water to enter until it is nearly full. When air pressure is applied from a compressor and air storage reservoir situated at any point of the system most convenient, the inlet valve is closed and water is delivered to the service piping. As faucets are opened at any point in the system the water is lowered in the first cylinder and the inlet valve in the other is opened, allowing water to enter there. When the first cylinder has been exhausted of its contents an automatic valve switches the supply to the second, and consequently the inlet valve of the first chamber opens again and water again enters. This process is repeated indefinitely so long as the air supply is maintained, and consequently a steady supply of water to the plumbing or other fixtures is available.

The air supply may be automatically controlled by a pressure control of switches if an electric motor is used to drive the air compressor, or if a gasoline engine is used the pressure control may be used to stop the engine when the desired pressure has been obtained in the air reservoir, leaving the starting to be done periodically by hand. In small systems the air pressure may be maintained by a hand pump and attention need only be given to it at intervals depending upon the amount of water used. A system operating on this principle is illustrated in Fig. 96, which shows the arrangement of air storage tank, air compressor and motor. A conventional diagram of the submerged pump is shown in Fig. 97 and its actual appearance in Fig. 98. Where the supply required is large, two or more pumps may be used to maintain a steady stream of water. It is then necessary to use a compressor and storage tank of larger capacity, but the arrangement is not changed in any way.

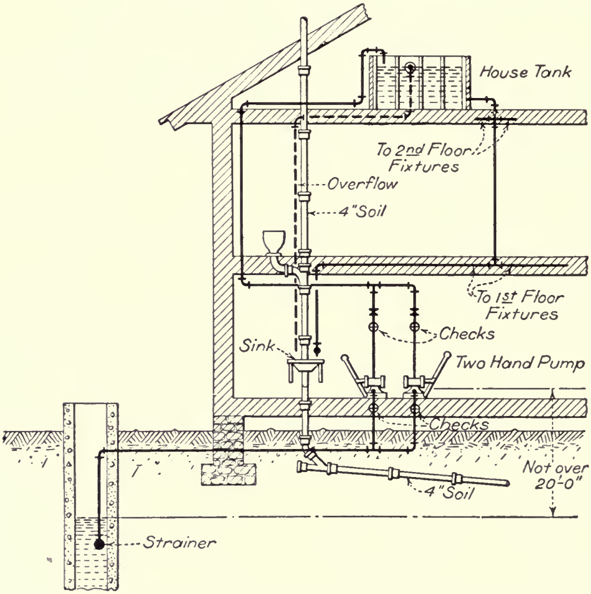


FIG. 94—OVERHEAD TANK FILLED BY HAND PUMPS

Pneumatic Storage-Tank System of Water Supply.

The storage tank system of water supply requires primarily a large steel tank in which the confined air is compressed by the entrance of water at its lower side. The compression of the air creates the artificial head necessary to raise the water to the desired level. As the lowering of the water level in the tank consequent upon drawing water at any of the points on the supply system necessarily lowers the pressure available the tank must be of sufficient capacity to provide a steady supply before the water level has fallen so far as to have insufficient pressure to force the water to the fixtures. It is generally estimated that the compression of the confined air to a quarter of its volume is equal to providing a pressure of 50 lb. at the tank, but the frictional resistance of the piping must be considered in making provision for a supply to a point to which this pressure would raise water and the absorption of some of the confined air by the water as the pressure increases also must be considered.

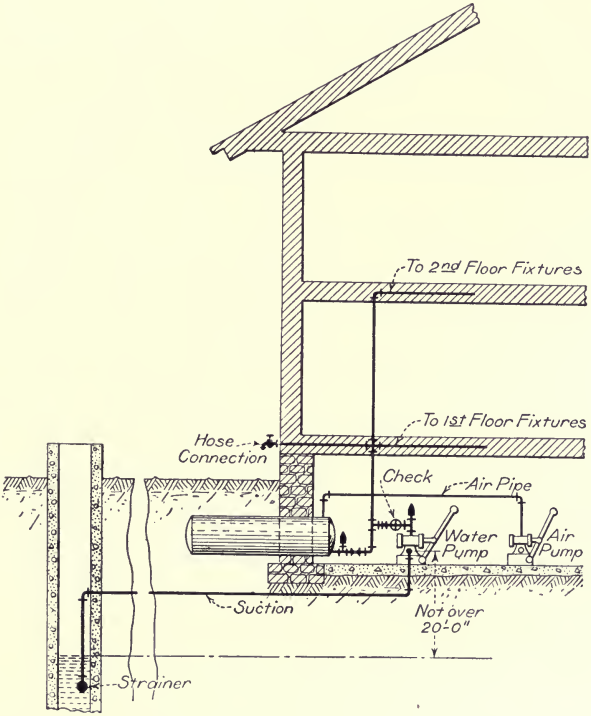


FIG. 95—HAND OPERATED PNEUMATIC SYSTEM OF WATER SUPPLY

It can be estimated that the amount of water contained between the highest level to which the tank fills and that at which a pressure of say 5 lb. in excess of the corresponding static pressure of a column of water equal in height to that of the height of the fixture above the tank will be supplied. Thus if the fixture is 15 ft. above the tank level a net pressure of 6.5 lb. would be required to raise water to that height and in an ordinary system to compensate for frictional losses and give a fair flow, an additional 5 lb. pressure would be required, a total of 11.5 lb. pressure at the tank. Under average conditions the tank will be filled to about one quarter of its capacity at that pressure and to about three-quarters of its total capacity at 50 lb. pressure, therefore about 1/2 of the total contents can be discharged to a height of 15 ft. when the tank has been pumped to show a pressure of 50 lb. at the start. The accompanying tables give the actual capacity and discharge of pneumatic tanks at various heights.

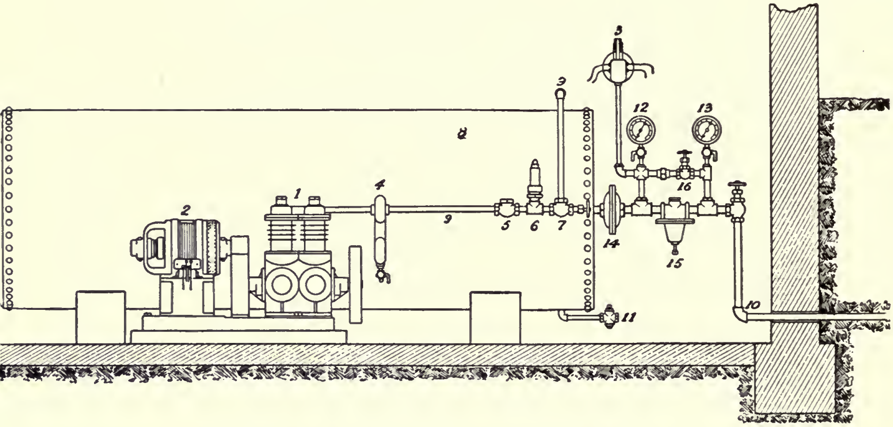


FIG. 96—AIR STORAGE TANK AND CONNECTIONS

Handy Tables from Which Capacity of Tanks and Pressure Required to Maintain Steady Supply May Be Calculated.

A study of Table 1 will show that where the quantity of water needed is large and the height very great this method has its advantages and involves practical obstacles not encountered in a gravity system or in any of those self-regulating direct-supply systems operating automatically with a steam or electric pump outfit. It is well to state here that the initial pressure numbers in this table contemplate that all the water in a tank can be delivered at the highest faucet if necessary, as a tank containing water and air pressure adequate to supply the lower floors but not the upper ones seems faulty and wrong. The remedy seems to be to raise a high initial air pressure that would keep water in the risers to supply all the floors while any water remains in the tank.

The purpose of this table is to show at a glance what these initial pressures should be for the given volumes and heights met with in general work. The wider use of the table will be best understood after the following brief outline.

All numbers within the square bounded by the heavy border lines indicate initial pressures. The numbers on the top row outside the border line are the given heights. The fraction numbers in the column headed "Fractional Volumes" denote tanks filled to the corresponding fraction of their capacity.

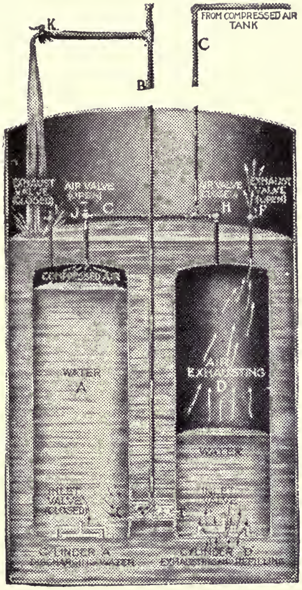


FIG. 97—DIAGRAM SHOWING OPERATION OF SUBMERGED PUMP

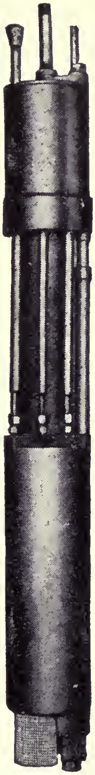


FIG. 98—TYPE OF NON-STORAGE SYSTEM PUMP

The mixed numbers in the column headed "Total Capacity" are to obtain the capacity of a tank by Rule 1, which reads: Multiply the number of gallons to be held, by the fractional volume, by its total capacity factor numbers.

The decimals in the column headed "Heights of Segments" are to find the height water should rise in a horizontal tank to contain a fractional volume by Rule 2, reading: Multiply diameter of tank in inches by the segment decimal for the fractional volume.

The decimals given in column headed "Heights of Verticals" are to obtain the water level in an upright tank by Rule 3, reading: Multiply height decimal given for fractional volume by length of tank in inches.

				HEIGHTS IN FEET ABOVE PRESSURE TANK FRACTIONAL VOLUMES WILL BE DELIVERED																							
HEIGHTS OF VERTICALS	HEIGHTS OF SEGMENTS	TOTAL CAPACITY	FRACTIONAL VOLUMES	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	FRACTIONAL VOLUMES	TOTAL CAPACITY	HEIGHTS OF SEGMENTS	HEIGHTS OF VERTICALS
0.10	0.157	10.00	1/10	4	6	9	11	14	16	18	21	23	26	28	31	33	35	38	40	43	45	47	50	1/10	10.00	0.157	0.10
0.11	0.167	9.00	1/9	5	7	10	12	15	17	19	22	24	27	29	32	34	36	39	41	44	46	49	51	1/9	9.00	0.167	0.11
0.13	0.183	8.00	1/8	5	7	10	12	15	17	20	22	24	27	29	32	35	37	40	42	45	47	50	52	1/8	8.00	0.183	0.13
0.14	0.200	7.00	1/7	5	8	11	13	16	18	20	23	25	28	30	33	36	38	41	43	46	48	51	53	1/7	7.00	0.200	0.14
0.17	0.223	6.00	1/6	5	8	11	14	16	19	21	24	26	29	31	34	37	39	42	44	47	50	52	55	1/6	6.00	0.223	0.17
0.20	0.254	5.00	1/5	7	9	12	15	17	20	23	25	28	31	33	36	39	41	44	47	50	52	55	58	1/5	5.00	0.254	0.20
0.22	0.274	4.50	2/9	7	10	13	16	19	21	24	27	29	32	35	37	40	43	46	49	52	54	57	60	2/9	4.50	0.274	0.22
0.25	0.298	4.00	1/4	8	11	14	17	20	22	25	28	31	34	36	39	42	45	48	51	54	57	60	63	1/4	4.00	0.298	0.25
0.28	0.328	3.50	2/7	9	12	15	18	21	24	27	30	33	36	39	42	45	48	51	54	57	60	63	67	2/7	3.50	0.328	0.28
0.30	0.340	3.34	3/10	10	13	16	19	22	25	28	31	34	37	40	43	46	50	53	56	59	62	65	69	3/10	3.34	0.340	0.30
0.34	0.367	3.00	1/3	11	14	17	20	24	27	30	33	37	40	43	46	50	53	56	59	63	66	69	73	1/3	3.00	0.367	0.34
0.37	0.401	2.67	3/8	12	16	19	23	26	30	33	37	40	44	47	50	54	57	61	64	68	71	75	78	3/8	2.67	0.401	0.37
0.40	0.421	2.50	2/5	14	17	21	25	28	32	35	39	42	46	49	53	57	61	64	68	71	75	79	82	2/5	2.50	0.421	0.40
0.43	0.444	2.34	3/7	15	19	23	27	30	34	38	41	45	49	53	57	61	64	68	72	76	79	83	87	3/7	2.34	0.444	0.43
0.45	0.457	2.25	1/9	16	20	24	28	32	35	39	43	47	51	55	59	63	66	70	74	78	82	86	90	4/9	2.25	0.457	0.45
0.50	0.500	2.00	1/2	19	24	28	32	37	41	45	50	54	58	63	67	71	76	80	84	89	93	97	101	1/2	2.00	0.500	0.50
0.56	0.543	1.80	5/9	23	28	33	38	43	48	53	58	62	68	72	77	82	87	92	97	101	106	111	116	5/9	1.80	0.543	0.56
0.57	0.556	1.75	4/7	25	30	35	40	45	50	55	60	65	70	75	80	85	91	96	101	106	111	116	121	4/7	1.75	0.556	0.57
0.60	0.579	1.67	3/5	28	33	39	44	50	55	60	66	71	77	82	87	93	98	104	109	115	120	125	130	3/5	1.67	0.579	0.60
0.63	0.599	1.60	5/8	31	36	42	48	54	60	65	71	77	83	88	94	100	106	112	117	123	129	135	140	5/8	1.60	0.599	0.63
0.67	0.633	1.50	2/3	36	43	49	56	62	69	75	82	88	95	102	108	115	121	128	134	140	147	153	160	2/3	1.50	0.633	0.67
0.70	0.660	1.43	7/10	42	49	56	64	71	78	85	93	100	107	115	122	129	136	143	151	158	165	172	180	7/10	1.43	0.660	0.70
0.72	0.672	1.40	5/7	45	52	60	67	75	83	90	98	106	113	121	128	136	144	151	159	166	174	182	190	5/7	1.40	0.672	0.72
0.75	0.702	1.34	3/4	53	62	71	79	88	97	105	114	123	132	140	149	157	167	175	183	192	201	210	218	3/4	1.34	0.702	0.75
0.78	0.726	1.29	7/9	62	72	81	91	101	111	120	130	140	150	160	170	179	189	199	208	218	228	238	248	7/9	1.29	0.726	0.78
0.80	0.746	1.25	4/5	71	81	92	103	114	125	136	146	157	168	180	190	201	212	222	233	244	255	266	277	4/5	1.25	0.746	0.80
0.84	0.777	1.20	5/6	87	101	114	127	140	153	166	179	192	205	218	231	244	257	270	283	296	309	322	335	5/6	1.20	0.777	0.84
0.86	0.800	1.17	6/7	104	120	135	150	166	181	196	211	226	242	257	272	287	303	318	333	348	363	378	393	6/7	1.17	0.800	0.86
0.87	0.817	1.14	7/8	121	139	157	174	192	209	226	244	261	278	296	313	330	348	365	382	400	417	435	452	7/8	1.14	0.817	0.87
0.89	0.833	1.13	8/9	139	159	178	198	217	237	257	276	295	315	335	354	374	393	413	432	452	472	491	510	8/9	1.13	0.833	0.89
0.90	0.843	1.11	9/10	156	178	200	222	243	265	286	308	330	352	373	395	417	439	460	482	503	525	547	569	9/10	1.11	0.843	0.90
HEIGHTS OF VERTICALS	HEIGHTS OF SEGMENTS	TOTAL CAPACITY	FRACTIONAL VOLUMES	MAXIMUN INITIAL PRESSURES REQUIRED TO DELIVER FRACTIONAL VOLUMES AT HEIGHTS.																				FRACTIONAL VOLUMES	TOTAL CAPACITY	HEIGHTS OF SEGMENTS	HEIGHTS OF VERTICALS

REFERENCE TABLE OF PRESSURE AND VOLUME FOR CLASS 2 PRESSURE TANKS.

TABLE I—FACTOR NUMBERS USED IN PROPORTIONING WATER SUPPLY TANKS

To facilitate the locating of a pressure number these four columns of factors are printed on each side of the central square. The following reference examples will serve as guides for any example that can be worked out by the aid of this table.

Example 1. If a tank only three-eighths full contains 625 gallons, what is its capacity? If the tank is 42 in. in diameter and is set horizontally, how high will the water level be when it is three-eighths full? What must the initial pressure be to deliver this quantity of water at a height of 65 ft.?

Solution: By the table, the capacity factor for the fractional volume three-eighths is 2.67, then by Rule 1, 625 × 2.67 = 1668 gallons equals the total capacity of the tank. The coefficient for the segment is found to be the decimal 0.401. Then by Rule 2, 42 × 0.401 = 17 in. as the height of the water level. Looking across the table on the $\frac{3}{8}$-fractional volume row to the height column 65, the initial pressure number found is 54.

Example 2. What must the capacity of a tank be so three-fifths of it will hold 497 gallons? How high will the water level be in a tank 6 ft. 3 in. long set upright? To deliver this quantity 50 ft. high what initial gauge pressure must be raised in the tank?

Referring to the table as in problem 1 and finding the capacity factor of fractional volume 3/5, we obtain by Rule 1, 497 × 1.67 = 830 gallons, capacity of tank.

Rule 3 gives 75 × 0.6 = 45 in., height of water level. Now following down the 50 ft. height column to fractional volume row 3/5, the initial pressure number for this height and volume is 77 lb.

The foregoing examples illustrate the simple arithmetical method used for applying any or all the numbers in the table. Like all ready reference numerical factors and coefficients the resultants are not always mathematically exact, but they are practically correct.

In air-tight water tanks, in which water entering at the base of the tank compresses the imprisoned air, the energy is utilized to force the water out of the tank to reinforce automatically or otherwise replenish a diminishing volume of flow at an open faucet or supply pipe.

The object and use of Table 2 is to aid one in finding what the capacity of these service-connected pressure tanks must be to hold in storage a reserve quantity of water sufficient to maintain a constant supply at the fixtures.

The available reserve quantity must be contained in a fractional part of the tank and the volume of this fractional part being dependent on the pressure of the entering water from the service main supplying the tank, it is necessary in order to deliver a required quantity when needed from a pressure tank operating on these principles, that the tank be proportioned so that it will be adequate to the varying demands.

The following examples illustrate the use of the table for this purpose:

Rule: Select the factor number from the lower left-hand square at the intersection of the pressure and height lines corresponding to the pressure and height lines of the problem. Multiply the number of gallons required to be held in storage by the factor number so found. The product will be the capacity of the pressure tank required.

Example: What must be the capacity of a pressure tank to hold and deliver 27 gallons at a height of 39 ft. from a pressure of 30 lb.?

Solution: Referring to the table in the lower left-hand square at the intersection of the 30-lb. and 39-ft. lines the factor number is found to be 7.33. Then by the rule 27 × 7.33 = 198 gallons, or a tank of 200-gallon capacity.

TABLE II—FACTORS WHICH MAY BE USED TO DETERMINE CAPACITY OF STORAGE TANKS

FRACTIONAL VOLUME OF TANK FILLED	PRESSURE IN LBS. PER SQ. INCH	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	PRESSURE IN LBS. PER SQ. INCH	FRACTIONAL VOLUME OF TANK FILLED
$\frac{14}{17}$	75	1.41	1.45	1.50	1.55	1.59	1.64	1.69	1.74	1.78	1.83	1.90	1.93	1.98	2.04	2.09	2.14	2.19	2.25	2.31	2.36	2.42	2.47	2.53	2.59	2.65	2.71	2.77	2.84	2.90	2.96	3.03	3.09	3.16	3.23	3.30	3.37	3.44	3.50	3.58	3.66	3.73	3.81	3.89	3.97	4.05	4.13	75	$\frac{14}{17}$
$\frac{9}{11}$	70	1.43	1.47	1.52	1.57	1.62	1.67	1.72	1.77	1.81	1.87	1.94	1.97	2.00	2.08	2.13	2.19	2.25	2.30	2.36	2.42	2.48	2.54	2.60	2.66	2.72	2.79	2.85	2.92	2.99	3.05	3.12	3.19	3.26	3.34	3.41	3.48	3.56	3.63	3.72	3.80	3.88	3.96	4.04	4.13	4.22	4.31	70	$\frac{9}{11}$
$\frac{13}{16}$	65	1.45	1.50	1.55	1.60	1.65	1.70	1.75	1.80	1.85	1.91	1.98	2.02	2.07	2.13	2.18	2.24	2.30	2.36	2.42	2.49	2.55	2.61	2.67	2.74	2.81	2.87	2.94	3.01	3.09	3.16	3.23	3.31	3.38	3.46	3.54	3.62	3.71	3.78	3.87	3.96	4.05	4.14	4.23	4.33	4.42	4.52	65	$\frac{13}{16}$
$\frac{4}{5}$	60	1.48	1.53	1.58	1.63	1.68	1.74	1.79	1.84	1.90	1.95	2.03	2.07	2.13	2.19	2.25	2.31	2.37	2.43	2.50	2.56	2.63	2.70	2.77	2.84	2.91	2.98	3.06	3.13	3.21	3.29	3.37	3.45	3.53	3.62	3.71	3.79	3.89	3.97	4.07	4.17	4.27	4.36	4.47	4.57	4.68	4.79	60	$\frac{4}{5}$
$\frac{11}{14}$	55	1.51	1.56	1.62	1.67	1.72	1.78	1.84	1.89	1.95	2.01	2.09	2.13	2.19	2.26	2.32	2.39	2.45	2.52	2.59	2.66	2.73	2.81	2.88	2.96	3.05	3.11	3.20	3.28	3.37	3.45	3.54	3.63	3.72	3.82	3.91	4.01	4.11	4.21	4.32	4.43	4.54	4.66	4.78	4.89	5.02	5.14	55	$\frac{11}{14}$
$\frac{7}{9}$	50	1.55	1.60	1.66	1.72	1.78	1.84	1.90	1.96	2.02	2.08	2.16	2.21	2.27	2.34	2.41	2.48	2.56	2.63	2.71	2.78	2.86	2.94	3.02	3.11	3.19	3.28	3.37	3.47	3.56	3.66	3.76	3.86	3.97	4.07	4.18	4.30	4.41	4.52	4.66	4.78	4.91	5.04	5.18	5.32	5.47	5.62	50	$\frac{7}{9}$
$\frac{3}{4}$	45	1.60	1.66	1.72	1.78	1.84	1.90	1.96	2.03	2.09	2.16	2.26	2.31	2.35	2.45	2.53	2.61	2.69	2.77	2.85	2.94	3.03	3.12	3.21	3.31	3.40	3.51	3.61	3.71	3.82	3.94	4.05	4.17	4.29	4.42	4.55	4.69	4.82	4.95	5.11	5.27	5.42	5.58	5.75	5.93	6.11	6.30	45	$\frac{3}{4}$
$\frac{8}{11}$	40	1.66	1.72	1.78	1.86	1.92	1.99	2.06	2.13	2.20	2.28	2.38	2.43	2.52	2.60	2.68	2.77	2.86	2.95	3.05	3.15	3.25	3.36	3.46	3.57	3.69	3.81	3.93	4.06	4.19	4.32	4.42	4.61	4.76	4.91	5.07	5.24	5.41	5.57	5.78	5.98	6.18	6.39	6.62	6.85	7.09	7.35	40	$\frac{8}{11}$
$\frac{7}{10}$	35	1.74	1.81	1.88	1.95	2.03	2.10	2.18	2.26	2.34	2.43	2.55	2.61	2.70	2.80	2.87	3.00	3.10	3.21	3.33	3.45	3.57	3.70	3.83	3.96	4.10	4.25	4.40	4.56	4.73	4.90	5.08	5.27	5.47	5.67	5.89	6.12	6.35	6.57	6.87	7.15	7.44	7.75	8.09	8.43	8.80	9.20	35	$\frac{7}{10}$
$\frac{2}{3}$	30	1.85	1.92	2.00	2.09	2.17	2.26	2.35	2.45	2.54	2.64	2.78	2.85	2.90	3.09	3.20	3.33	3.46	3.60	3.75	3.90	4.05	4.21	4.39	4.56	4.76	4.95	5.16	5.38	5.62	5.86	6.12	6.43	6.69	7.00	7.33	7.69	8.07	8.42	8.91	9.37	9.90	10.45	11.07	11.74	12.47	13.28	30	$\frac{2}{3}$
$\frac{5}{8}$	25	2.00	2.09	2.19	2.29	2.39	2.50	2.61	2.72	2.84	2.97	3.15	3.24	3.39	3.54	3.70	3.87	4.05	4.24	4.44	4.65	4.87	5.11	5.37	5.63	5.93	6.24	6.57	6.94	7.33	7.75	8.21	8.71	9.27	9.87	10.55	11.30	12.14	12.97	14.17	15.41	16.84	18.48	20.53	22.94	25.91	29.67	25	$\frac{5}{8}$
$\frac{3}{5}$	20	2.23	2.35	2.48	2.61	2.74	2.88	3.03	3.19	3.35	3.53	3.79	3.92	4.14	4.37	4.61	4.88	5.17	5.48	5.82	6.19	6.59	7.04	7.53	8.07	8.69	9.37	10.12	11.04	12.06	13.25	14.66	16.34	18.41	20.96	22.71	28.65	34.72	42.55	58.82	88.50	172.41	2000.00					20	$\frac{3}{5}$
$\frac{1}{2}$	15	2.67	2.83	3.02	3.20	3.41	3.63	3.86	4.13	4.40	4.72	5.19	5.45	5.87	6.35	6.88	7.50	8.19	9.00	9.96	11.08	12.45	14.14	16.29	19.05	22.88	28.33	36.76	52.08	87.83	244.00																	15	$\frac{1}{2}$
$\frac{2}{5}$	10	3.72	3.95	4.31	4.72	5.17	5.71	6.31	7.03	7.86	8.95	10.79	11.96	14.22	17.39	22.08	29.94	45.25																														10	$\frac{2}{5}$
$\frac{1}{4}$	5	8.09	9.73	12.25	16.13	23.02	39.84																																									5	$\frac{1}{4}$
		5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50		
		$2\frac{1}{8}$	$2\frac{3}{5}$	3	$3\frac{1}{2}$	4	$4\frac{1}{3}$	$4\frac{3}{4}$	$5\frac{1}{5}$	$5\frac{3}{5}$	6	$6\frac{1}{2}$	7	$7\frac{2}{5}$	$7\frac{4}{5}$	$8\frac{1}{4}$	$8\frac{7}{10}$	$9\frac{1}{10}$	$9\frac{1}{2}$	10	$10\frac{2}{5}$	$10\frac{4}{5}$	$11\frac{1}{4}$	$11\frac{7}{10}$	$12\frac{1}{5}$	$12\frac{3}{5}$	13	$13\frac{1}{2}$	14	$14\frac{3}{10}$	$14\frac{3}{4}$	$15\frac{1}{8}$	$15\frac{3}{5}$	16	$16\frac{1}{2}$	17	$17\frac{2}{5}$	18	$18\frac{3}{10}$	$18\frac{7}{10}$	19	$19\frac{1}{2}$	20	$20\frac{2}{5}$	21	$21\frac{3}{10}$	$21\frac{7}{10}$		

FACTOR NUMBERS TO SIMPLIFY CALCULATIONS IN PROPORTIONING THE CAPACTY OF SERVICE CONNECTED PRESSURE TANKS.

Again, height, 27 ft. — pressure 55 lb. — quantity required 19 gallons. By referring to the table it is found that 19 × 2.88 = 55 gallons as the capacity of a tank required in this case. These two examples show the method of applying any of the factors in the table.

Having a pressure of water not corresponding to those given in the table and requiring the size of the tank, the table may be used as follows:

Rule: Select the factors for the next highest and the next lowest pressure numbers to it. Add them together and divide their sum by 2. Multiply the quotient by the number of gallons needed; the product will equal the capacity of pressure tank required.

Example: What must be the capacity of a pressure tank to deliver 9 gallons from a water pressure of 28 lb. to a height of 45 ft.? Thirty lb. and 25 lb. are the next highest and the next lowest for this pressure number not shown in the table, and their factors at the 45-ft. height equal 9.90 and 16.84, respectively; then by the rule: $(9.90 + 16.84) \div 2$ equals 13.37, and 13.37×9 equals 120-gallon capacity.

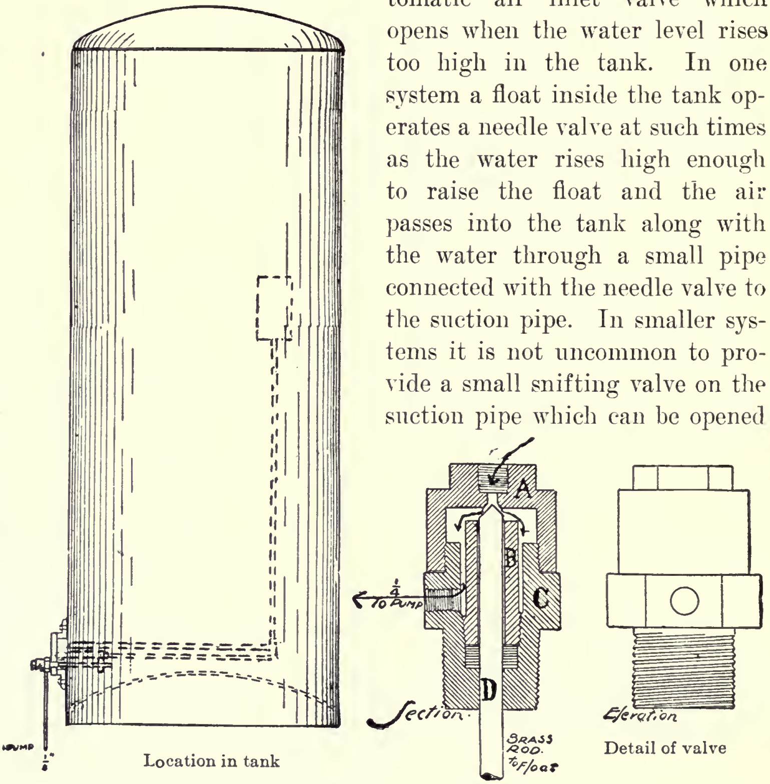
Another method which may be used for the above is to multiply the number of gallons needed by each factor separately; add the two products together and divide their sum by 2. This method will also give the capacity of pressure tank needed for such pressures as are not given in the table. Thus, by this rule, and applying it to the above problem $(9.90 \times 9) + (16.84 \times 9) = 240$ gallons and $240 \div 2 = 120$, the same answer.

If only one factor is used for this class of problem, preference should be given the one for the larger tank. *Note*—By using the factors as divisors, the number of gallons that can be delivered to a specified height from a pressure tank of known capacity by a given water pressure is readily obtained.

Example: Having a pressure tank of 500-gallon capacity, how many gallons will it deliver to a height of 31 ft. from a pressure of 45 lb.? The factor found in the table for these numbers is 3.61, then $500 \div 3.61 = 138$ gallons.

The foregoing brief explanation outlines the use of this table and serves as a key or reference for readers interested in this class of pressure tanks; especially when such pressure tanks are being considered as a means to reinforce an inadequate water supply or of their being used as auxiliary feeders to pumps and flushometers, special air chambers, etc.

The absorption of air by the water in a closed tank in time reduces the capacity of the tank to deliver water unless means are provided for renewing the air supply. This is generally accomplished by the provision of an auxiliary air pump or air compressor operated in connection with the water pump or by an automatic air inlet valve which opens when the water level rises too high in the tank. In one system a float inside the tank operates a needle valve at such times as the water rises high enough to raise the float and the air passes into the tank along with the water through a small pipe connected with the needle valve to the suction pipe. In smaller systems it is not uncommon to provide a small snifting valve on the suction pipe which can be opened at such times as the water gauge shows that the water level is rising too high.



Location in tank

Detail of valve

FIG. 99—NEEDLE VALVE AIR RENEWAL APPLIANCE

The automatic float and needle valve is shown in Fig. 99, together with the air pipe connected with the pump suction pipe.

In large systems it is common to provide a separate air compressor to maintain the air contents of the tank at the proportions desired.

If electricity is used for power it is easy to control the system automatically. This is accomplished by a pressure regulator which operates a switch and stops and starts the motor as the pressure rises or falls below the desired point. With a gasoline or other engine the control is not so easily effected, but it is common to provide a pressure actuated control which stops the gasoline engine when the required pressure has been produced in the tank. As it is generally only necessary to pump for a short time each day if a plant of sufficient size has been installed the engine can be started by hand without much trouble and the automatic appliance depended upon to stop it when enough pumping has been accomplished.

Fire Protection in Isolated Buildings.

The principal requirement in fire-protection systems in country buildings where the system must be relied upon as an efficient protection rather than as an auxiliary until the regular fire-fighting equipment can be brought into service is an ample supply of water. If this is available at a fair pressure the installation of a system of fire lines is a simple matter and merely requires the running of pipes in convenient locations and the provision of branches with lengths of hose which will enable the occupants to reach any point of the building from the standpipe or hose connection to the various fire lines.

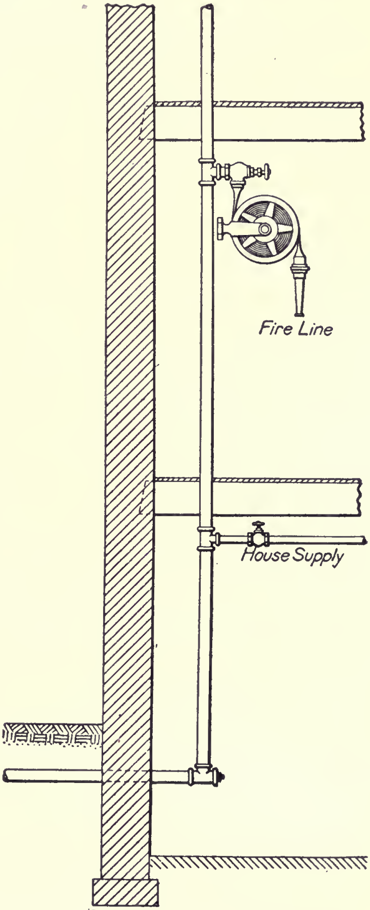


FIG. 100—FIRE LINE CONNECTIONS FOR COUNTRY HOUSE

When the supply is taken direct from the main pipe outside of the building there should be no valve intervening between the hose connections and the curb cock outside of the building. The house connection may be made as shown in Fig. 100, that is, the valve controlling the supply for domestic purposes should be placed on a branch line so that there will be no danger of the supply being closed on the fire lines inadvertently.

If the supply to the buildings comes from a spring by gravity the same method of making the connection should be followed or a special line should be brought in for fire purposes alone. If it is desired to make provision for a connection to the fire engines so that a supply may be pumped into the inside lines on their arrival, the special line is advisable, as then a check valve may be fitted inside the building in the basement and another on the main supply line, and the connection made as shown in Fig. 101. If this is done the connection may be made to the steamer and pumping begun with the certainty that the pressure in the lines will not be lost through the existence of an open end or trouble be experienced through a closed valve.

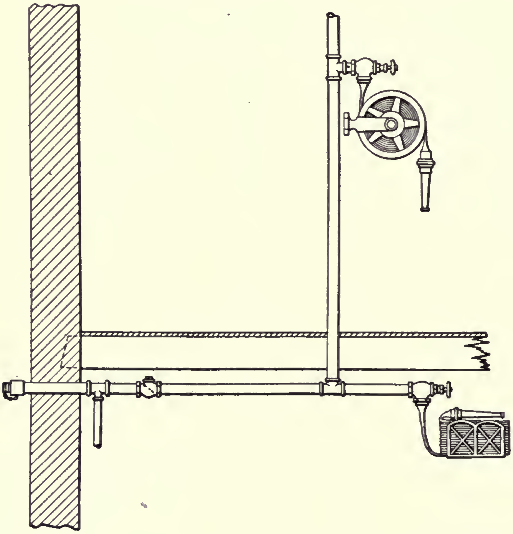


FIG. 101—CONNECTIONS WHERE SIAMESE HOSE FITTING IS USED

If the supply to the buildings is pumped, a fire-protection tank should be erected either on the roof or at some convenient point which will be high enough to provide a supply at a fair pressure. If the tank is on the roof the lines should be run as shown in Fig. 102. Here is shown a main drop pipe from the tank to the basement and two risers placed at convenient locations, preferably in stair wells or halls, so that the valves may be reached easily. On each floor hose connections are made and at each a length of hose sufficient to reach to a point where the hose from the other riser can meet it is provided. Thus every part of the building is equally protected.

Hose reels or racks should be provided at each connection and

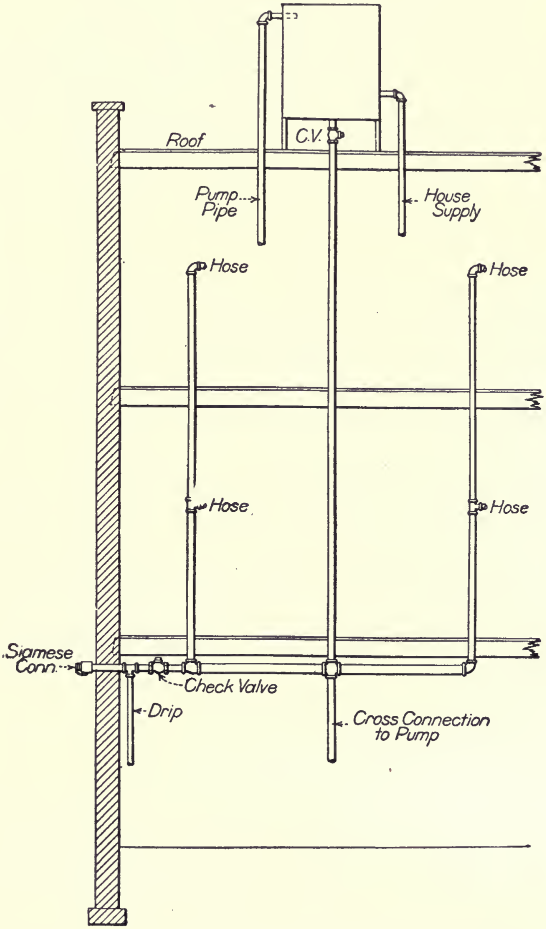


FIG. 102—FIRE PROTECTION SYSTEM SUPPLIED FROM HOUSE TANK

Underwriter's linen hose, which coils easily and takes up little room, is preferred. The reels or coils may be fastened to the wall or to the fire line. The latter is the better way as a type of rack or reel may be chosen which will revolve on a pivot and so make the removal of the hose more easy.

The fire line connection to such a tank must be made so that a definite quantity of water is held in reserve for fire-protection purposes. That is, if the house supply comes from the same tank, the house-service pipe must be connected at a point say half way up the tank, so that the lower half of the tank cannot be emptied excepting through the fire line or cleanout pipe. The amount of water held in reserve will depend entirely upon the size of the building and the amount of protection required.

If a steamer connection is made to the fire lines when a house tank is used there should be check valves at the points indicated. This prevents water from being wasted through overflowing the tank when the steamer is working and the lower check valve ensures that there will be no water in the outside Siamese connection, as a drain pipe outside of the check valve keeps it clear and so safe against the action of frost. The Siamese connection should be located in a position easily and quickly accessible. It is generally placed in front of the building to be protected and close to the wall, or projecting from it. In Fig. 103 is shown a good type of Siamese connection which has separate check valves in each arm, but others are available where one valve only is used. This allows either one or both arms to be connected up to the steamer, as the check operates automatically to close the opening when pumping ceases.

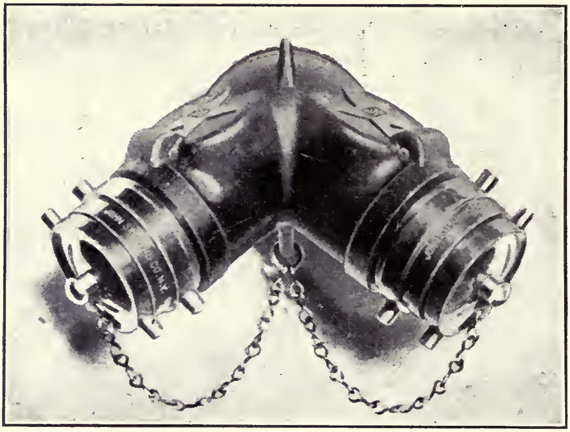


FIG. 103—SIAMESE FIRE CONNECTION WITH SEPARATE CHECKS

The size of the fire lines will depend upon the number of hose connections to be made and also upon the pressure available.

The sizes in general use are from 1¼-in. to 2½-in. The latter size is used in buildings of moderate to large size and throws a large stream. As nozzles for this size of hose have an area of opening of about 1 sq. in. it is customary to assume a pipe area equal to the sectional area of a 2-in. pipe for each hose nozzle in the building. Thus a fire line 3 in. in diameter would keep two full-size hose nozzles supplied and a 4-in. pipe would supply about 5 nozzles. These figures apply to low pressures such as would obtain from tanks placed on roofs or on towers of moderate height. If a heavy pressure is available the number would be increased or the water delivered at each nozzle much greater in volume.

If the fire-protection system is to be at all extensive and a special fire pump is to be used in connection with it there should be cross connections so that the house pump may be turned in to aid or to replace the fire pump in case of failure. The pumps are also arranged to that they will start automatically on the opening of a hose valve.

Sprinkler systems should be arranged according to the rules of the National Board of Fire Underwriters as then the decreased rate of insurance will be given. These requirements call for the use of two separate water supplies, one of which must be automatic and should furnish water under heavy pressure. For buildings of the type under consideration, namely, large country residences, schools and institutions, an elevated tank and a duplex steam pump or electric rotary pump may probably offer a good combination.

The elevated tank may be of the closed type and placed within the building, but at a sufficient height to ensure a good pressure. It may also act as an air-pressure tank to increase the available pressure at the sprinklers. The rules also govern the method of installing the piping and the sizes of mains and branches. The accompanying tables show how many sprinklers may be placed on pipes of the sizes given, the distance allowable between sprinklers in buildings of standard mill construction and with open joists.

The National Board of Fire Underwriters also stipulates the number of sprinklers which must be used for a given type of building. The accompanying tables give the distances between sprinkling heads in standard mill construction and open joisted buildings. The terms medium hazard and special hazard apply to the contents of the room. In all cases the distance from the walls to the nearest sprinklers should not be more than half the distance between the sprinklers in the same direction. The temperature at which ordinary sprinkler heads come into action is about 165 degrees F., but special types are also made for use in rooms where high temperatures must be maintained. Sprinklers of a type approved by the Underwriters should always be used.

NATIONAL BOARD OF FIRE UNDERWRITERS REQUIREMENTS

Number of Sprinklers Allowed on Pipes of Given Sizes

Pipe Size	Main Pipes	Branch Pipes
¾ in.	1	1
1 in.	2	2
1¼ in.	4	4
1½ in.	8	6
2 in.	16	8
2½ in.	28	16
3 in.	48	28
3½ in.	78	..
4 in.	110	..
5 in.	150	..
6 in.	200	..

DISTANCE BETWEEN SPRINKLERS FOR STANDARD MILL CONSTRUCTION

One Row of Automatic Sprinklers in Each Bay Placed Midway Between Beams
Water Pressure at Highest Sprinkler

	Over 20 Lb.		Under 20 Lb. or from Tank	
	Medium hazard	Special hazard	Medium hazard	Special hazard
In 12 ft. bays	8 ft. apart	7 ft. apart	7 ft. apart	6 ft. apart
In 11 ft. bays	9 ft. apart	8 ft. apart	8 ft. apart	7 ft. apart
In 10 ft. bays	10 ft. apart	9 ft. apart	9 ft. apart	8 ft. apart
In 9 ft. bays	11 ft. apart	10 ft. apart	10 ft. apart	9 ft. apart
In 8 ft. bays	12 ft. apart	11 ft. apart	11 ft. apart	10 ft. apart
In 7 ft. bays	12 ft. apart	11 ft. apart	11 ft. apart	10 ft. apart

DISTANCE BETWEEN SPRINKLERS FOR OPEN JOIST CEILINGS

(Sprinklers to be Placed Under Joists)
Water Pressure at Highest Sprinkler

	Over 20 Lb.		Under 20 Lb. or from Tank	
At right angle to joists..........	8 ft. apart	7½ ft. apart	7½ ft. apart	6½ ft. apart
Parallel to joists...	10 ft. apart	9 ft. apart	9 ft. apart	8 ft. apart

Sprinkling Systems for Greenhouses and Gardens.

The supply of water to sprinkling systems for gardens and greenhouses is preferably made from a gravity system operating under a fair pressure, but when this is not available an alternative method is to use a pneumatic tank or to pump directly into the sprinkling system from a gasoline-engine pump combination. The pneumatic tank offers an easy solution of such a problem as it may be made large enough to supply water for domestic and other purposes around the premises should that be desirable. If the supply is for sprinkling only the pump may be connected directly to the piping system leading to the sprinklers and a relief valve may be inserted at a point near the pump so that should the sprinklers be closed while the engine is running the water will be relieved and conducted back to the well if the supply is a short one.

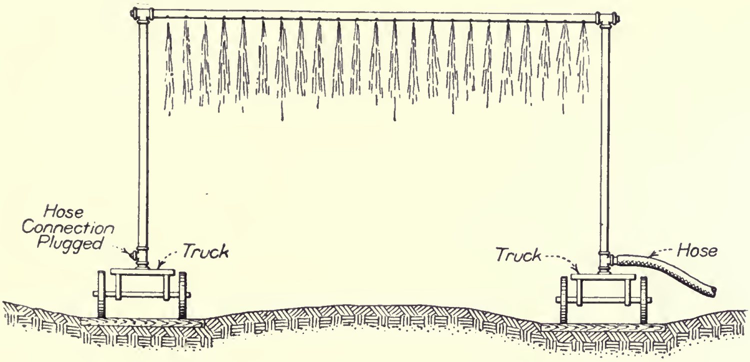


FIG. 104—TRAVELING SPRINKLER FOR LARGE GARDENS

Some makers make an engine and pump mounted on one base and with a relief valve incorporated in the construction especially for greenhouse use. The piping of the sprinkling system will depend upon the use to which it is to be put. Some gardeners prefer a travelling arrangement such as that shown in Fig. 104 where the sprinklers are mounted on a carriage and are moved along the side of the beds at will. In this case it is necessary to connect the piping by means of a hose and it is advantageous in such a case to provide hydrants at suitable intervals so that an excessive length of hose will not be required. In greenhouses overhead sprinklers may be preferred and in this case the connections may be made permanent. Other styles call for the fitting of sprinkling pipes along the side of the beds and so arranged as to throw the spray across. In all cases where pipes are laid outside and exposed to frost they should be made to drain properly so that in cold weather they may be left perfectly dry.

Overhead and other types of sprinklers are shown in Fig. 105. Where the sprinkling system is desired for use entirely with a hose, and the pipes must be laid underground several types of hydrants are available, a common pattern being shown in Fig. 106. Alternatively a hydrant may be made from ordinary water-supply fittings. In Fig. 107 is shown one made from a stop and waste cock, elbows and nipples. A heavy brass pin should be fastened through the head of the stopcock and the key used to turn it, so that it will not become corroded through dampness. If the lines of distributing pipes to the hydrants are long it may be necessary to use relays to secure a pitch sufficient to drain them in the winter season. This is easily done as shown in Fig. 108, where the pipe is raised about 6 in. at each relay and pitched down to the next, with a tee and drain cock at each. It is well to use a regular curb box at each so that the drain cock may be located with ease.

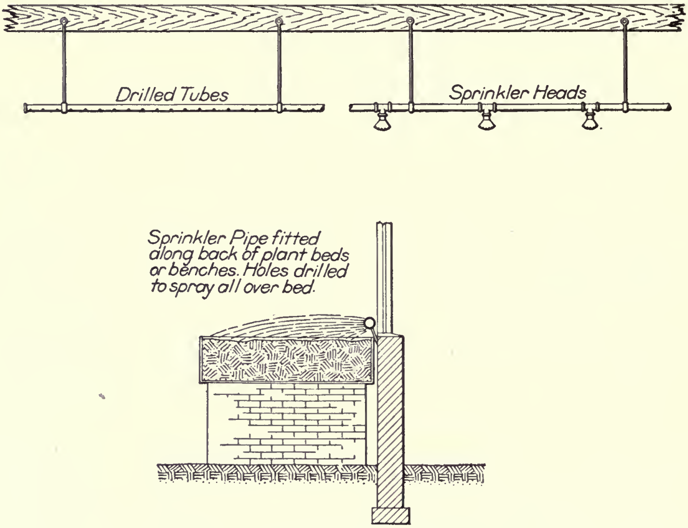

Drilled Tubes
Sprinkler Heads
Sprinkler Pipe fitted along back of plant beds or benches. Holes drilled to spray all over bed.

FIG. 105—OVERHEAD AND WALL SPRINKLERS FOR GREENHOUSES

In order to estimate the size of pipe required for a sprinkling system it may be assumed that at a moderate pressure, say 30 lb. per sq. in., a garden hose with a spray nozzle will deliver 6 gallons of water per minute and a lawn sprinkler of the whirling type about 8 gallons per minute. If a long sprinkling pipe is used with holes about the same size as those in a sprinkling head, and about 3 in. apart, each foot will deliver about 1 gallon per minute at 30 lb. pressure.

In long pipes the pressure loss is considerable and must be allowed for in proportioning the size of the main. The lower the initial pressure the greater the proportionate difference in the flow at the point of entrance and point of delivery will be. Thus if a pipe ½ in. in diameter will deliver 1 cu. ft. of water under a head of 30-lb. pressure at the connection to the main supply pipe, when it is continued 100 ft., the delivery will be only about half of that amount. If the initial pressure is 100 lb. per sq. in., the flow at the connection will be slightly over 2 cu. ft. per minute and at the end of a branch 100 ft. long about 1.22 cu. ft. per minute.

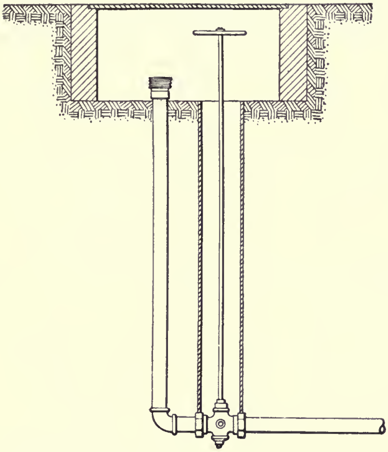


FIG. 107—GARDEN HYDRANT MADE FROM PIPE FITTINGS

Correspondingly, as the size of the pipe increases the reduction in the flow due to friction is less noticeable. For these reasons it is often advisable to make two small branch connections to a line carrying a number of hydrants or sprinklers rather than one connection of the full size of the pipe and at one end only.

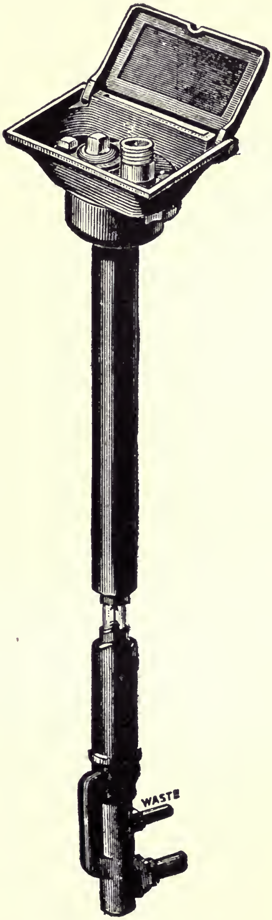


FIG. 106—HYDRANT AND SURFACE BOX

Multiple Connections to Water Mains.

In order to secure an ample supply of water to a building it is often necessary, when the main is comparatively small, to make several tappings rather than one of large size. If this were not done the strength of the main pipe might be seriously impaired.

The connection to the main pipe may be either of lead or iron pipe and the customary method is to make the two small pipes enter one of larger diameter through a tee or wiped joint. It is not good practice to use a tee "bullheaded" for this purpose. If connected as shown in Fig. 109, when water is being drawn freely through the branch pipes the pressure therein is reduced considerably, water flows at a high rate of speed through each of the tappings and meeting at the bullheaded tee creates considerable friction and is often the cause of a humming and disagreeable noise. The better way is to use Y's as shown in Fig. 110 when the water will flow into the branch line freely from either tapping and there will be no noise accompanying a heavy draft.

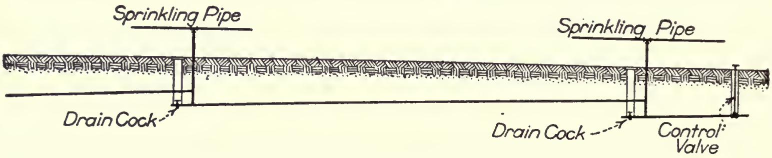


FIG. 108—LONG DISTRIBUTING PIPES LAID IN RELAYS TO FACILITATE DRAINING

To Freeze Service Pipes.

It sometimes happens that in order to stop the water supply to buildings so as to make repairs, that it is desirable to freeze the water in the service pipe. To do this, cut the service pipe temporarily, stop the flow of water by driving in a wooden plug, and then pack the pipe in a freezing mixture. The selection of a freezing mixture may be made from the following:

Five parts of sodium sulphate and four parts diluted sulphuric acid make a mixture which will reduce the temperature of water from 50 degrees F. to 3 degrees.

One part of ammonium nitrate and one part water will reduce the temperature from 40 degrees F. to 4 degrees.

Twelve parts crushed ice, five parts salt and five parts ammonium nitrate form a mixture which will reduce from the ordinary temperature of water to 25 degrees below zero.

Twenty-four parts of crushed ice, ten parts salt, five parts ammonium chloride and five parts potassium nitrate will make a mixture which will reduce the temperature of water to 18 degrees below zero.

Five parts of crushed ice, two parts salt and one part ammonium chloride will make a mixture which will reduce the temperature of water to 12 degrees below zero.

Two parts of crushed ice and one part of salt form a mixture which reduces the temperature of water to 5 degrees below zero.

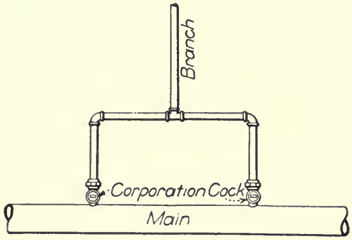


FIG. 109—METHODS OF SERVICE PIPES

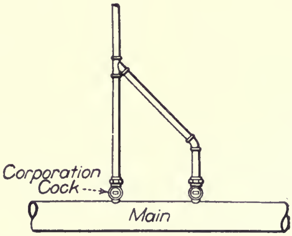


FIG. 110—CONNECTING TO MAINS

It depends upon how rapidly it is desired to freeze the pipe as to which mixture will be employed. The mixture must be packed around the pipe.

The phenomenon of freezing water in a pipe is similar to that of freezing ice cream, and this is explained as follows:

The action of a freezing mixture of salt and ice is due to the fact that salt is dissolved very readily in water and liquifies ice very rapidly. As ice cannot melt unless it receives heat from some other material, consequently an absorption of heat, which is necessary in order to permit the ice to liquify, must take place from the nearest available matter, which is at a higher temperature, so that in the case of freezing a service pipe the heat which is required to melt the ice is removed from the water within the pipe and the water freezes.

CHAPTER XII.

SEWAGE DISPOSAL FROM ISOLATED BUILDINGS. VARIOUS METHODS OF LIQUEFACTION, FILTRATION AND DISPOSAL.

When the now universally adopted system of purification and disposal of the wastes from cities or individual dwellings known as the biological method was first introduced a well-known English scientist characterized it as a return to nature. That is its best recommendation. It undoubtedly is a return to nature and nature has the power to correct matter, to readjust it and to render the offensive and dangerous matter harmless to the human race. It has taken long and patient study to discover how that return must take place. It is not to be thought that it is yet perfectly understood.

The history of sanitary science may be traced from very early times when the results of allowing the wastes from a large community to accumulate became evident and the spear shafts of the men were fashioned with a flat end with an obvious purpose. The fact that the shallower layers of the earth's surface had the power to absorb these wastes and to disintegrate them has been known through all these thousand of years and in some manner taken advantage of, but as times changed and the centers of population became more congested the fact was overlooked. People were getting away from nature. The return of the wastes to the earth became increasingly more difficult of accomplishment and they were allowed to accumulate in pits and in heaps. The result was disease and death. The progress toward a realization of this was slow. The history of the world is marked by a succession of times of plague and mysterious disease traceable in the light of modern knowledge to horrible sanitary conditions. These conditions have been improved but slowly, and it is only within the last century that any real advance has been made and within the last forty years of that century that the purification of waste matters has been really understood. While the engineer has taken a large part in the development of means for the inoffensive disposal of these wastes the chemist and bacteriologist have of necessity played the all-important part. They have formulated theories for the engineer to put into practice and calculated the value of the results the engineer's plant produced. Thus the present state of comparative efficiency has been reached.

Methods of Sewage Purification.

When the necessity for purification of sewage to prevent the pollution of the rivers and ground water of the country became evident through the general adoption of the water-carriage method of waste disposal the first methods adopted were those of chemical precipitation and sterilization. While the addition of chemicals produced a clear and apparently harmless liquid it was soon discovered that it rapidly became foul and that the volume of sludge which resulted presented a problem very difficult of solution. The fact that sewage when treated in this manner was not readily amenable to oxidization and that the consumption of oxygen from the dissolved air of a natural water is due to the presence of growing organisms was first presented by Dupre in a report to the English Local Government Board in 1884. In 1886 he again referred to it, proposing to cultivate the lower organisms on a larger scale for purposes of purification, and the theory was about this time put into practice by Dibdin, whose name has been associated with much of the progress in the science in consequence.

Thus the credit for the introduction of the biological method belongs to England, but in 1887 was established by the State Board of Health of Massachusetts, the experiment station at Lawrence, which has accomplished so much that it has really pointed the way to the engineering profession of the world in matters connected with sewage purification.

The matter of chemical treatment need not have any consideration here, as sewage disposal systems where this method of separating the organic wastes from the water in which they are carried is practiced are outside the scope of this work. Wherever sewage purification is necessary in order to dispose of the wastes of isolated buildings in a manner which will not create offensive or dangerous conditions, the biological method is adopted and that is likely to be the only method used in the future.

Briefly, this method calls for the hydrolysis or liquefaction of the solids and then the oxidization of the whole before the effluent is fit to pass into any but a large body of running water without risk of serious contamination. It is accomplished as follows:

The sewage as it flows from the building may be treated in a settling tank and screened to remove the matter which cannot be handled in the secondary part of the process of purification, the matter which settles and takes the form of sludge being removed periodically, but in small and medium-sized installations it is more common to employ what is known as a septic tank to effect the preliminary treatment. This is in effect a scientifically arranged and proportioned settling tank. Its purpose is to allow the sewage as it comes from the house to be acted upon by living organisms which are present in all waste matter of an organic nature and which are encouraged to multiply by providing the proper conditions. These bacteria thrive and perform their allotted work best when the temperature of the sewage is maintained around 60 degrees F., when light and air are excluded and when the flow of water through the tank is such that it will not disturb the surface.

The action is practically that of fermentation and as the bacteria do not require air to perform their work they are classed as "anaerobic bacteria." When the sewage has been subjected to action in this tank for a period varying between 12 and 18 hours the major part of the solids have been reduced and the insoluble matter and part of the organic matter has fallen to the bottom of the tank where a sludge gradually forms. As bacterial action still proceeds in the sludge the depth of this grows but slowly and it is only necessary to remove it at long intervals.

On the surface of the contents of the tank also there appears a scum which soon grows in thickness and is known as the matt. It grows more quickly where the liquids are exposed to light and air and is composed principally of grease and particles of matter which have floated to the surface through the accumulation of gas in its cells. A scum of moderate thickness is desirable as it accelerates the bacterial action, but if it should become very heavy the action is hindered rather than advanced, sludge is precipitated more rapidly and as a result the liquids pass through the tank faster than they ought to, owing to the reduction in capacity and the process of liquefaction is incomplete.

If, however, the proportions of the tank are right in the first place, the growth of the scum and sludge will be so slow that it will be many months before the capacity has been reduced to a point where it will be necessary to clean the tank.

The effluent of the tank may appear tolerably free from impurities, but should it be exposed to strong sunlight for a few hours it would become very offensive and is altogether unfit to be delivered into a small brook or lake. A further process is necessary before it can be considered fit to discharge into either a running stream or into the ground, where it may find its way to a well or other source of water supply.

In this secondary process another set of bacteria, known as aerobic bacteria because air is necessary to their existence is employed. As has already been stated these bacteria are ever present in the upper strata of the soil and, therefore, the most simple form of secondary treatment is to distribute the effluent from the septic tank over a considerable area in such a fashion as to take advantage of the presence of the aerobic bacteria and to cause them to break up the organic matter into harmless mineral forms which will be absorbed by the vegetable life on the surface. This is known as sub-surface irrigation and as the distribution must of necessity be made through perforated pipes or through pipes set with loose joints, it will be seen that some method of reducing the solids is absolutely necessary to prevent chokage of the distributing pipes and that either settlement or liquefaction is absolutely necessary before the sewage can be turned into the ground.

Alternatively the liquefied or screened sewage may be passed to a specially prepared bed or filter designed so as to propagate the aerobic bacteria and to afford the largest possible surface over which the effluent from the primary tank will pass in process of filtration so as to obtain the maximum of bacterial action. The different types of filtering beds will be described, but the construction of septic tanks should be understood first.

Many firms are making a specialty of building septic tanks of steel plates or cast iron, and these may be had in various sizes suitable for small and medium-sized disposal plants. They may be placed either underground or in a basement as convenient, but while the latter position has certain advantages in the way of ease of access to make connections and easy maintenance of the required temperature even in extremely cold weather, it has obvious disadvantages when it becomes necessary to remove sludge. In most cases it will be found expedient to place the septic tank outdoors and if sufficient pitch can be secured it may be placed at a sufficient depth below the surface to ensure that it will not be affected injuriously by frost. Besides, the warmth of the water flowing from the house is generally sufficient to keep the contents at a high enough temperature to secure effective action.

The tank shown in Fig. 111 is illustrated as being placed inside the cellar to show how the connections would be made in such a case. It is also shown in a position close to the house and at some distance from it so that the matter of location is really one to be decided upon according to local conditions. This tank is provided with an automatic appliance for emptying the contents into the disposal field at stated intervals and the time is governed by the

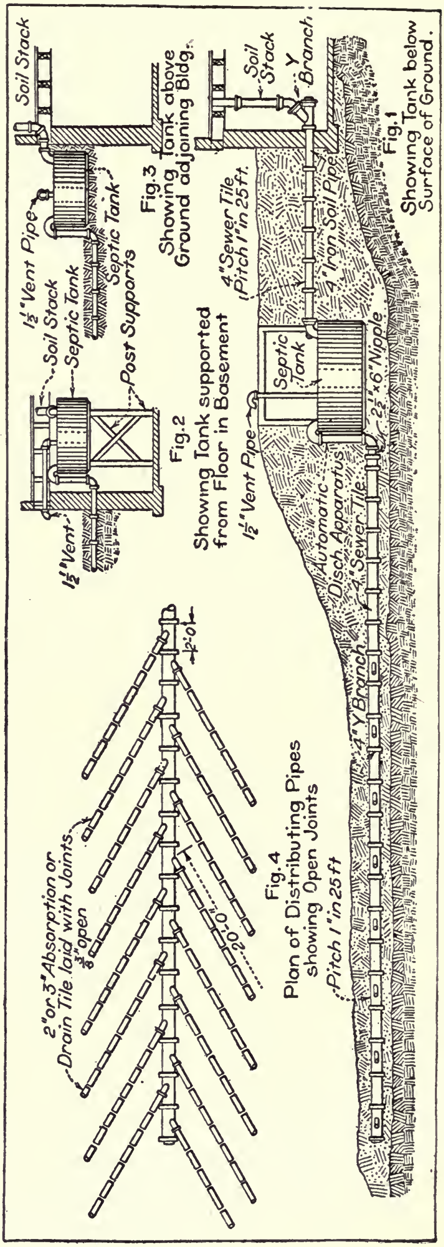

Soil Stack
1½" Vent Pipe
Soil Stack
Septic Tank
Septic Tank
Post Supports
Fig.3
Showing Tank above Ground adjoining Bldg.
1½" Vent
Fig.2
Showing Tank supported from Floor in Basement
1½" Vent Pipe
Soil Stack
Y Branch
4" Sewer Tile
(Pitch 1" in 25 ft.
4" Iron Soil Pipe
Fig.1
Showing Tank below Surface of Ground.
Septic Tank
2½"×6" Nipple
Automatic Disch. Apparatus
4" Sewer Tile
4" Y Branch
12'-0"
2" or 3" Absorption or Drain Tile laid with Joints ⅜" open
20'-0"
Fig.4
Plan of Distributing Pipes showing Open Joints
Pitch 1" in 25 ft

FIG. 111—SUB-SURFACE SYSTEM OF SEWAGE DISPOSAL SHOWING VARIOUS LOCATIONS OF SEPTIC TANK

dimensions of the tank as it is proportioned according to the number of occupants served and the daily flow of sewage and waste water.

Construction of Septic Tanks.

Various other styles of tanks built of steel or cast iron and incorporating similar features to that illustrated are available, but by far the greater number are built of brick or concrete. These concrete tanks are generally, though not necessarily, of an oblong shape and are constructed along the lines of that illustrated in Fig. 112. It is constructed in two parts because it is desirable that the contents should be distributed over the filter bed or disposal field of a sub-surface irrigation system periodically rather than continuously. Therefore, the part containing the siphon or at least subject to siphonic action is built of a size which will contain the flow of sewage from the building in a period of 8 hours, while the other part is constructed to hold one day's flow. Thus if the amount of water used in a residence, which is the best guide as to the amount of sewage discharged, is 500 gallons per day, then the larger tank will be made to hold that amount and the smaller about 175 gallons. Thus a discharge will be made approximately thrice a day, although the intervals of time may not be equal owing to the greater use which is made of the plumbing equipment during the daytime.

The construction of the tank may be varied to suit any conditions. It may with all propriety be circular in shape or it may be drawn in at the top instead of having a flat surface. In all conditions, however, the following rules must be observed:

The inlet must be made in such a fashion that the sewage will avoid disturbing the contents. This is best done by taking the pipe to a point below the surface, or a baffle board may be constructed at the inlet point as shown in Fig. 112 so that the entering water will be forced to take a downward direction. This is advisable for another reason. If a deflecting board or wall is not provided the current may carry the entering matter across the tank to the outlet end in such a manner that it will be carried through to the siphon chamber without having had time for proper bacterial action. If a baffle board is provided the contents will be more likely to pass through the whole length of the tank and the solids are more likely to be diffused through the tank, and consequently liquefied to a much greater extent.

As a means of removing the sludge more easily, the bottom may be made in the form of a pit tapering to the bottom. If an outlet pipe of fairly large diameter is connected to the bottom of the pit and a proper fall is available, a considerable quantity may be removed by gravity when it is necessary to clean the tank. It may also be pumped out on occasion and special diaphragm pumps are made for this purpose. The tapering bottom or sump facilitates the process considerably.

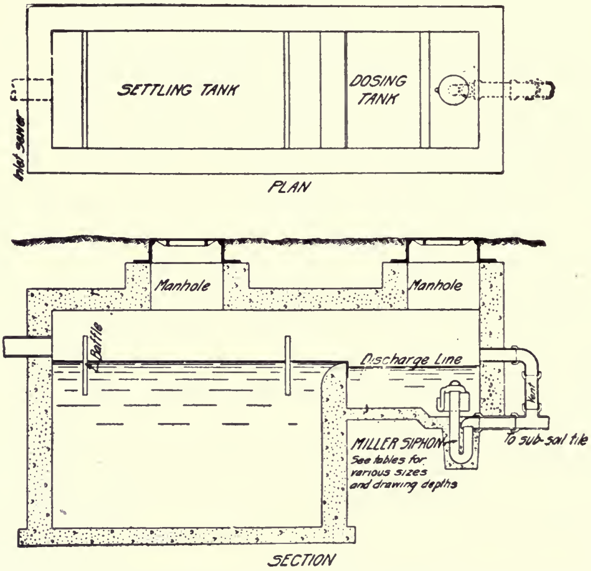


FIG. 112—PLAN AND ELEVATION OF SEPTIC TANK WITH DOSING CHAMBER EMPTIED BY SIPHON

Septic Tank Made from Sewer Tiles.

A simple form of septic tank may be constructed from sewer tile as shown in Fig. 113. This form is not suitable for other than small installations owing to the restrictions imposed by the size of tile pipe available, but for a residence with one bathroom and occupied by a small family it gives satisfactory results.

The inlet from the house drain and the outlet to the discharge chamber should be made through bends as indicated. The tiles should be set in a bed of concrete about 6 in. in depth to form the bottom of the tank and the two chambers forming the septic tank proper should be connected together as indicated. If this is done there will be a certainty that the contents will pass through without disturbance and also that the entire contents will be treated properly.

A tank of the dimensions given will handle satisfactorily about 250 gallons per day, delivering the contents of the tank to the disposal field at intervals of about 6 hours. In practice there will be a period of greatest flow when the time between discharges will be less but it is unlikely that these will be so close as to flood the bed if properly constructed. The disposal bed is built of 2-in. and 4-in. tile pipe laid in the customary manner.

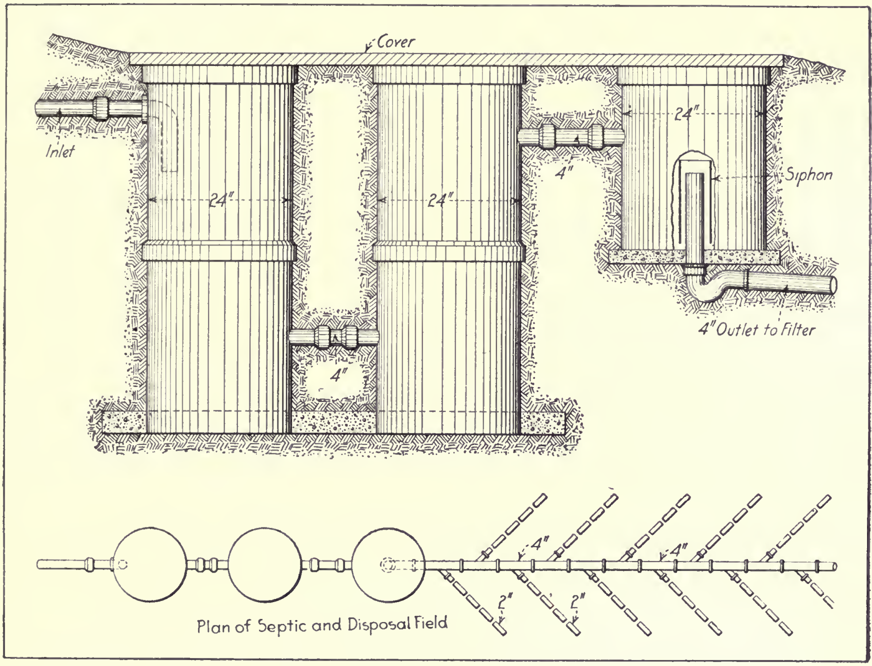


FIG. 113—SIMPLE SEPTIC TANK CONSTRUCTED OF SEWER PIPE

Siphons for Septic Tanks.

Siphons suitable for use in septic tanks may be made from ordinary pipe fittings if desired. It is necessary to provide a deep seal trap below the level of the tank and an ordinary siphon bend inside it but the length of the leg, or part between the seal of the lower trap and the crown of the siphon bend is of some importance in determining the reliability of the siphon. When this type of siphon is used a relief pipe, generally galvanized iron, is tapped into the crown of the siphon bend and carried down to a little above the level of the lower part or inlet to the siphon. This enables the siphon to draw air and break the vacuum sufficiently to stop the siphonic action when the tank is emptied.

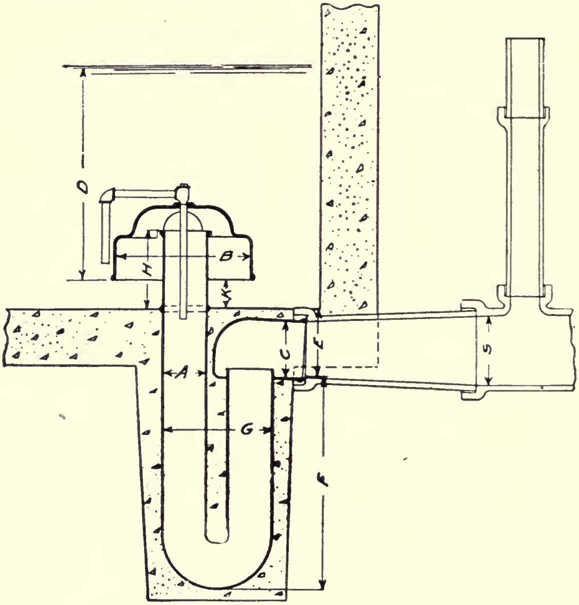


FIG. 114—SECTION THROUGH MILLER SIPHON SHOWING ARRANGEMENT OF VENT PIPES AND DISCHARGE

Efficient siphons made of cast iron are available and are more generally used than those made from pipe fittings as they are simpler to install and access to the outlet drain is easier with them also. A common form, the Miller siphon, is illustrated in Fig. 114.

As the smaller tank fills up the water rises in the bell of the siphon also and compresses the air imprisoned between the bell and the seal of the deep trap which forms the lower leg of the siphon. The pressure is soon sufficient to force some of this imprisoned air through the seal of the trap and at length is so much above the pressure in the part between the bell and the seal that the contents of the trap are moved bodily into the outlet leg. This causes a loss of seal and as water passes over the bell to replace that driven out of the trap the long leg of the siphon becomes filled and in consequence the contents of the tank are discharged with a rush, until the water line has fallen to a point below the small pipe which enters the top of the bell. This admits air and as soon as the pressure of the atmosphere is equal on both sides of the bell the siphonic action ceases. The siphon is made in sizes from 3 in. to 8 in. in diameter, but the size generally found suitable for use in medium sized disposal plants such as might be required for a country residence is the 3-in. or 4-in. size.

A Siphon which Requires no Trap.

The Stary improved automatic siphon for use in connection with septic tanks shown in Figs. 115 and 116 consists of only three parts and no deep seal trap is required in addition to the siphon proper. The action is as follows:

The siphon is sealed by filling the trap on the bell with water. When the water entering the tank rises above the level of the lower edge of the in-taking limb or bell the air within becomes trapped. The continued rise of water in the tank compresses the air confined within the siphon and this compression gradually forces the water from the trap until the water in the tank has reached

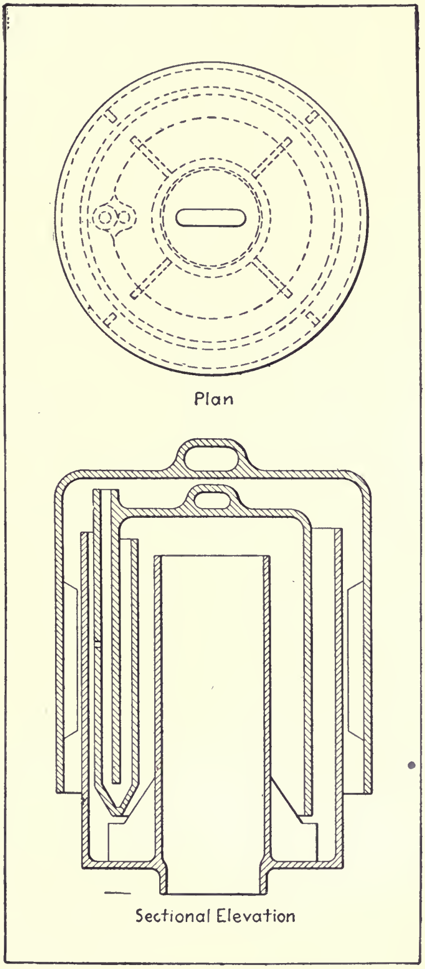


FIG. 115—PLAN AND SECTION THROUGH STARY SIPHON

sufficient depth to draw the liquid seal, when the confined air suddenly escapes and the water from the tank rises in the bell, bringing the siphon into full operation instantly. The water is then drawn from the tank to a level with the lower edges of the bell, air enters the siphon and the operation is repeated as soon as the tank fills again.

Where it is not possible to empty the septic tank by means of a siphon owing to lack of sufficient pitch to the disposal bed, mechanical means may be employed. A sewage ejector may be used for this work although the appliance is primarily designed for the raising of sewage from fixtures in basements to a level at which it may be delivered to the sewer. A sewage ejector with features which make it applicable to the work of distributing the contents of a septic tank is illustrated in Fig. 117.

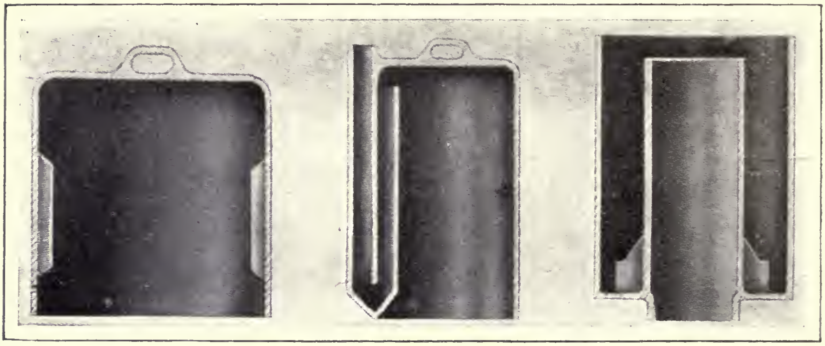


FIG. 116—COMPONENTS OF THE STARY SIPHON

In operation, as the liquid rises in the collecting tank or in this case the dosing tank, a float rises with it and at the height at which it is desired to discharge the tank the float throws a switch and starts the motor attached to the horizontal centrifugal pump which is operated below the water line as seen in the illustration. As soon as the pump has lowered the contents of the tank to the level of the suction inlet the float throws the switch again, the electrical circuit is opened and remains open until the water fills the tank. With this type of pump it is necessary that the operating mechanism be placed directly over the tank but if it is not convenient to erect a shelter at the septic tank it may be advisable to construct the dosing tank at some distance from the septic tank, connecting them with a pipe which leaves the septic tank at the top by means of a sealed outlet as shown in Fig. 118. Another type of mechanical discharge employs buckets in place of the pump but wherever possible the use of mechanical appliances should be avoided and the siphon used.

Contact Beds and Trickling Filters.

An addition to the means of filtration which also affords further opportunity for bacterial activity before the effluent is discharged into the soil is given by the provision of what is termed a contact bed or cultivation tank. When used as an auxiliary to the septic tank and previous to the application of the liquids to a subsurface irrigation bed or a sand filter the contact bed is arranged something like that shown in Fig. 119. As constructed it simply forms an intermediate chamber between the septic tank proper and the siphon chamber. In this case the septic tank performs largely the function of settlement while the partly broken-up solids and the matter in solution or suspension are carried down through a bed of broken stone, coke breeze or other material affording a large area upon which bacteria may be propagated and so into the discharge chamber. Thus the tank is discharged periodically, aerating the contact bed as it does so and providing a fresh supply of oxygen to the interstices of the bed. This arrangement however is seldom used as it is found that the septic action is sufficient to break up the solids and to fit the effluent for final treatment in the sand or other filter or in the disposal field.

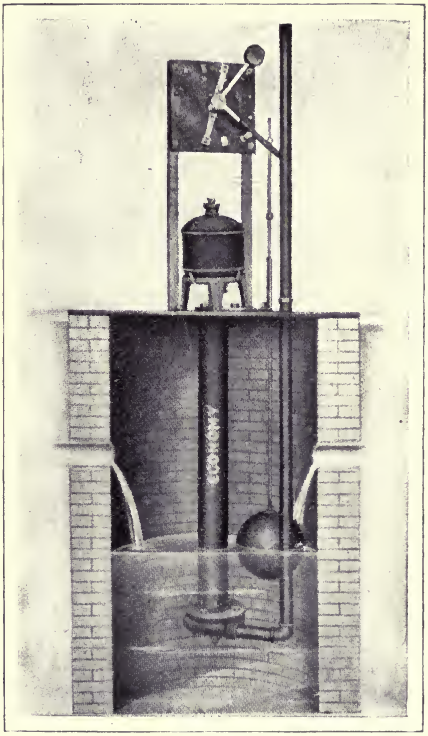


FIG. 117—THE ECONOMY SEWAGE EJECTOR

A very simple form of septic tank and filter which is sometimes called a septic cesspool is shown in Fig. 120. As the term implies, this is simply a tight cesspool, constructed however to favor bacterial action as much as possible by ensuring a quiet flow through the tank and a retention for the proper length of time of its contents. The overflow from the tank is caused to pass through a bed of broken stone which is provided with aerating pipes and thus a large surface is made available for the oxidization of the liquids before they seep away into the soil. The benefit resulting from this construction is that the surrounding soil will not become sick or clogged with organic matters so readily as it would were the matter to be discharged without any opportunity for aerobic bacteria to act upon it or for the supply of oxygen to the water passing from the tank being renewed.

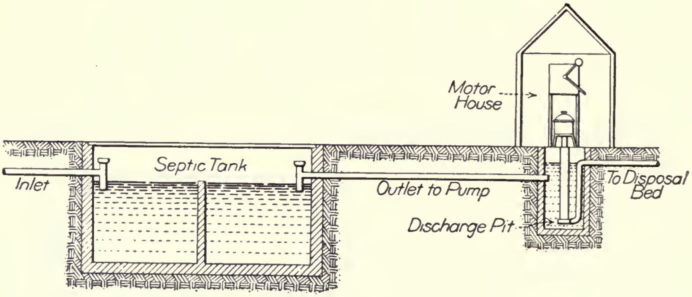


FIG. 118—METHOD OF DISCHARGING CONTENTS OF SEPTIC TANK BY AUTOMATIC PUMP

As shown, the aeration is accomplished by pipes carried down into the bed and by a proper grading of the material so that the interstices will be large enough to admit of free circulation while the water flowing from the inner tank will pass over the bed in a thin film, giving the greatest opportunity for oxidization and nitrification.

If the soil is of such a heavy nature that liquids are not readily absorbed another addition to this arrangement of septic tank and filter may be used, this simply taking the form of a collecting well from which a pump pipe may be led. Then the liquids may be pumped and distributed over an irrigation tract or delivered into a brook with comparatively little fear of a nuisance developing. It will be necessary to remove the sludge from the inner tank at intervals varying according to the nature of the sewage and the proportions of the tank to the amount of flow, so it is well to make provision for this. A diaphragm pump may be used for this work with advantage.

Filters and Distributing Ducts or Fields.

Possibly the simplest and most widely used method of disposing of the effluent from a septic tank is that known as sub-surface irrigation. This calls for the employment of tile pipe laid in such a manner that the liquid is free to leak from the joints and is laid as shown in Fig. 121. It will be seen from the illustration that the pipe leaving the septic tank is of the regular bell and spigot type and the joints of this portion are made with cement as it is not desired that there will be any seepage until the disposal bed has been reached. At the point where the distribution is to begin, a distributing chamber is constructed. This is simply a brick pit with one inlet and two outlets, each of which leads to an equal amount of pipe laid as shown in the illustration.

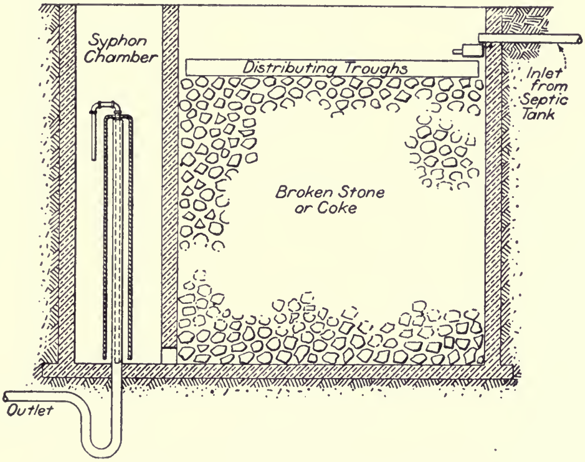


FIG. 119—SECTION THROUGH A CONTACT BED OR FILTER

The purpose in laying the pipe in this fashion is to afford an opportunity of diverting the flow to one side or other of the bed periodically so that the soil may become rested and have time to be replenished with oxygen during the period that the flow is being taken care of by the other section. If this is not done the soil may become water logged and "sick" when practically no purification will take place and a nuisance will be the result. Simple sluices or valves shown in Fig. 122 are constructed in the deflecting chamber which may be operated at such times as the flow of sewage may determine. If a sufficient amount of tile pipe is provided, once in two weeks may be sufficient and another factor which will determine the length of time that the ground will receive the sewage and effect satisfactory purification is the nature of the ground. A light and porous soil will do longer and better work than one of a heavy nature.

Many engineers assume that each foot of tile pipe laid in the above fashion will take care of a gallon of sewage which has previously been treated in a septic tank. Thus if the daily flow were 500 gallons a bed containing 500 lineal ft. of pipe would probably do good work if the nature of the soil were suitable, but it is advisable to use much more generous proportions and 5 ft. to 1 gallon may not be too much in many conditions. If the ground is heavy the pipe may be laid in trenches partly filled with stone or cinders, or the ground all over the bed may be broken up and mixed with cinders to increase the capacity for absorption of water and the free circulation of air through the soil. Upon this latter depends more than anything the success of the system.

The pipe lines are generally laid at a distance of about 5 ft. apart and are usually of 3-in. diameter field tile. These have no hubs and are simply laid end to end with about ½ in. intervening between lengths. To prevent dirt from finding its way into the pipe and so obstructing the flow of water, it is customary to cover the upper side of the joint. For this various substances are used including salt hay and tarred paper, but the best method is to procure half tiles and lay them over the joints as shown in Fig. 123. It is also well to cover the pipes to the depth of several inches with broken stone or gravel so that air may have free access. The pipes should be laid at a depth of about 18 in., as at a great depth there will not be free circulation of air and the soil will in consequence become sick.

If the climate is more than usually severe and it is feared that the tiles may become frozen in winter, or if the soil is of a heavy or damp nature, the trenches should be made deeper and filled with stone to a depth of 12 in. before the pipe is laid. At the bottom of the ditch an underdrain may be laid in the same manner as the distributing tile.

Thus there will be two pipes, one over the other at a distance of 12 in. apart and separated by broken stone as shown in Fig. 121, and when this plan is followed there may be a depth of 18 in. of soil filled in over the top of the upper pipe. In cold weather there will be little chance of such a distributing field becoming frozen as there is always a fair amount of heat in the entering sewage and the depth at which the pipe is laid is sufficient to prevent the loss of heat rapidly enough to allow of the ground becoming frozen below the pipe line.

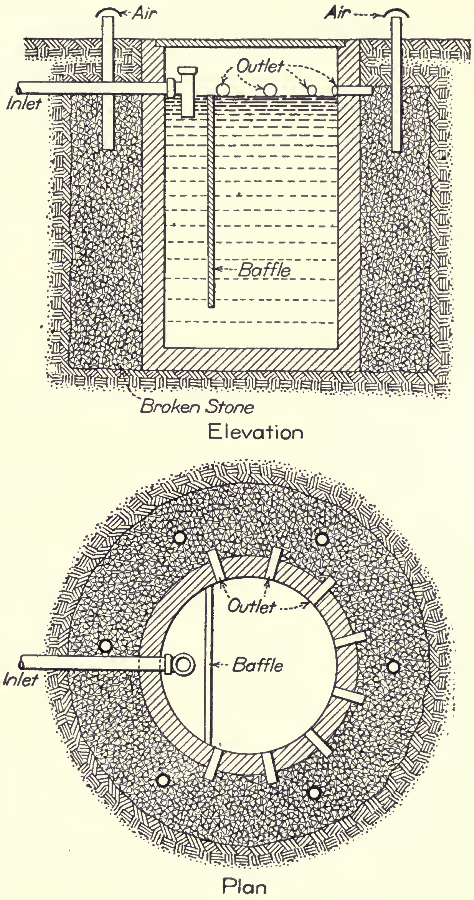


FIG. 120—DETAILS OF AN IMPROVED CESSPOOL

In place of the ordinary field tile special distributing pipes are sometimes used. These have outlets provided as shown in Fig. 124 and are placed so that the flow of water into the soil is facilitated while the joints of the pipes may be made with cement if desired and so dirt be prevented from finding its way into the bore and choking them. If this pipe is used where it is necessary to use sub-drains, the lower pipes should be of the usual field tile variety or the joints of the lower pipe should be laid in the reverse manner so that the water will flow into the lower pipe naturally instead of backing up against the grade as would be the case were the joints to be made with cement and the pipes laid with the outlets placed in the direction of the flow. In either case if sub-drains are necessary and the pipes are laid at considerable depth it will add to the efficiency of the distributing bed so far as oxidization of the liquids passed into it is concerned if the lower part of the drain is ventilated by extending a length of pipe to the surface at intervals of 15 ft. or so.

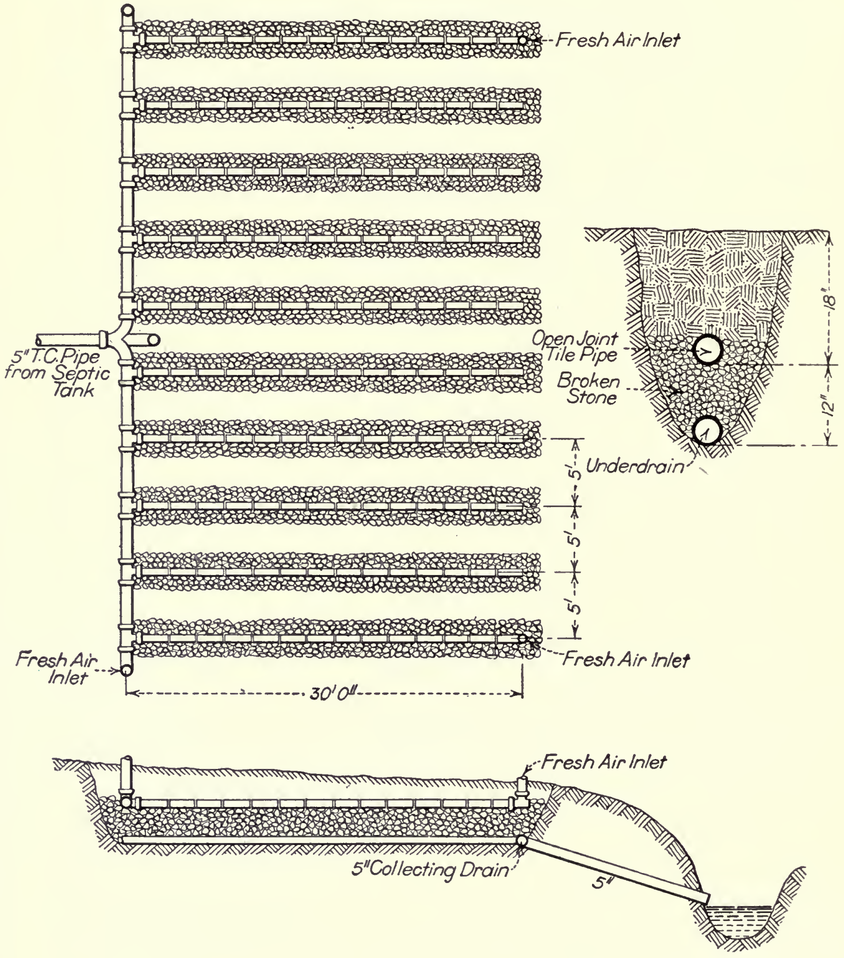


FIG. 121—PLAN AND SECTIONS THROUGH SUB-SURFACE IRRIGATION BED SHOWING METHOD OF SUB-DRAINING AND AERATING THE DISPOSAL BED

If the soil is of an exceptionally favorable nature it may not be necessary to provide any deflecting chamber and in this event the distribution may be effected by running one pipe down the center of the disposal ground and carrying distributing pipes from Y's placed on that pipe. This method is shown in Fig. 111. The same distance should be maintained between the distributing lines however, so that ample space will be given for proper aeration of the soil. If the pipes are too close together the water when discharged into the soil from the pipes will not pass away so rapidly and in consequence air will not be drawn down through the porous earth above the pipes with so great facility to replace that utilized in the process of oxidizing the sewage.

What are termed nitrifying ducts are constructed in a similar manner to the distributing ducts of a sub-surface irrigation system in a patented system of sewage disposal. They virtually amount to a trickling filter constructed underground, as by continuing the sub-drain to the open, a current of air is induced through the pipe and consequently the bed of broken stone which extends the whole length of the duct and in which the distributing and aerating pipes are laid. It is claimed that by passing the effluent from a septic tank through this extended duct in close contact with the air which the open end provides, the process of nitrification and oxidization is complete and the effluent is of first class quality.

Distributing Chambers and Valves.

In Figs. 125 and 126 are shown the septic tank and distributing chambers used in some Federal buildings. The septic tank has a capacity of 18,000 gallons and is constructed with a submerged baffle wall and submerged inlet and outlet pipes. It is constructed entirely of concrete and has a manhole for access. The distributing chamber which accommodates the valves by which the flow from the tank may be diverted to one or the other side of the field is also built of concrete. The main outlet from the dosing chamber in connection with the septic tank enters the chamber in a gutter in the base of the chamber and is divided into two channels. A pipe connects with each channel and leads the effluent to one or more distributing ducts constructed as already described, and according to the requirements of the soil, with or without stone filling in the ditches. At the mouth of each of these pipes, and inside of the chamber flap valves are placed. These are intended to be operated as it is found desirable to allow one or other of the sides of the disposal bed to rest and renew the oxygen in the earth or stone bed so that the bacteria may do efficient work.

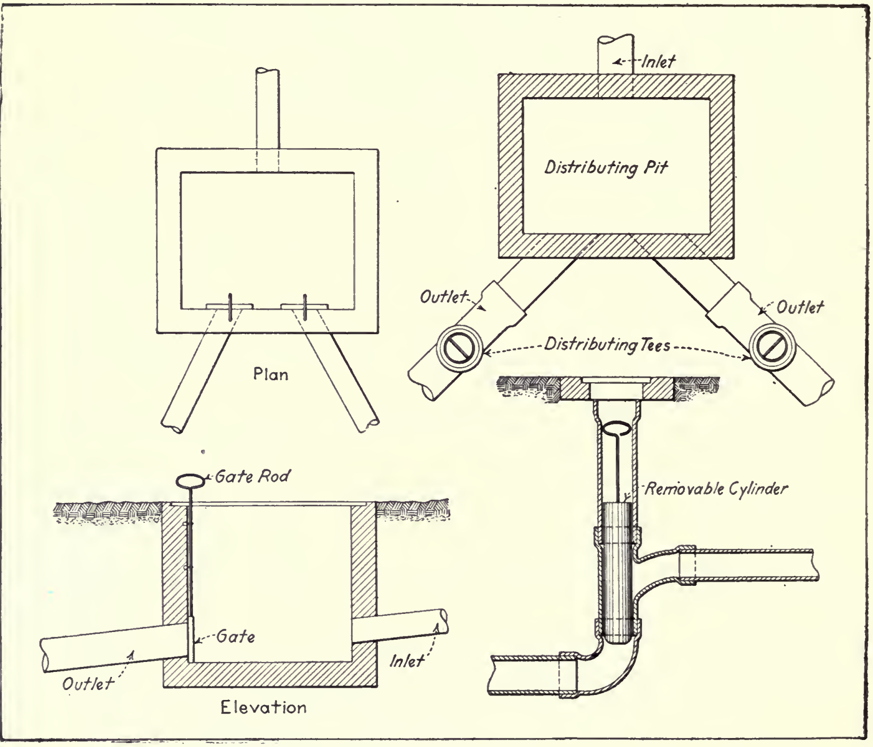


FIG. 122—PLANS AND SECTIONS THROUGH DISTRIBUTING PITS SHOWING TWO METHODS OF DIVERTING FLOW TO DIFFERENT SECTIONS OF DISPOSAL FIELD

In the illustration in Fig. 122 the valves shown are of the most simple nature. One that serves the purpose admirably simply consists of a cylinder which is inserted into one or other of the tees shown in the illustration, as it is desired to direct the flow to one side or other of the bed. It may be stated also that the quantity of sewage handled by a disposal field may be increased by underdrain-ing the disposal tiles. The underdrains may be laid at a depth of about 2 ft. and the ditch filled with loose stone to a depth of 3 in. or so above the pipe. Then the disposal tile is laid and stone filled over that to a depth of 3 in. If the soil is very heavy it may be advantageous to mix it with ashes when filling the remainder of the ditch and occasionally an entire field is prepared by digging up the soil and making it more fit to absorb moisture by the addition of cinders and other absorbent materials.

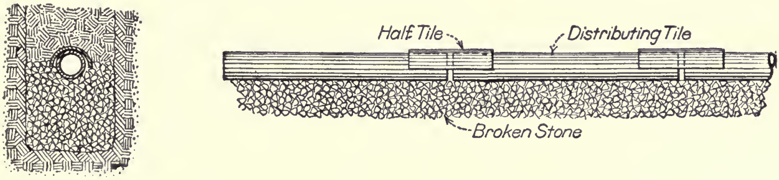


FIG. 123—METHOD OF PREVENTING SAND ENTERING DRAINS

The reason for the periodical discharge from the septic tank is also bound up in the state of the soil. If the discharge were constant and trickling there would be considerable risk of the soil becoming clogged with organic matter around the first few pipes. When the whole contents of the tank are discharged at one time the liquid is delivered equally over the entire bed and as it rapidly percolates into the soil it draws air behind it and in consequence there is an ample supply of oxygen to replace that consumed in oxydizing the previous discharge and the bacteria are thereby enabled to continue their work to advantage. In the absence of any heavy discharge like this the air becomes exhausted of oxygen, the bacteria cannot exist and in consequence the organic matter collects around the points at which it is delivered, becomes putrid and offensive, and the soil is gradually clogged until it can receive no more liquids.

Sprinkling and Trickling Filters.

Trickling, percolating, or sprinkling filters are simply beds of broken stone constructed so as to provide a large area of surface over which the previously treated sewage may be caused to flow in a thin film. As it passes over the stones it is acted upon by aerobic bacteria which have been cultivated in the gelatinous substance which soon collects in the interstices. The bed is built of stone of different sizes according to the nature of the sewage to be treated but a good size for use in installations of the nature suitable for small residences and other buildings is about 1 in. x 2 in. x 1 in. thick. This has been found to afford good circulation of air while it assures that the liquid will remain in contact with the bacteria long enough in its passage through the filter to ensure proper clarification and reduction of the organic matter.

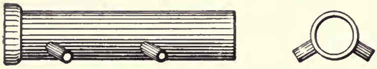


FIG. 124—TILE DRAIN WITH SIDE OUTLETS

The filter may be constructed as shown in Fig. 127 or it may be placed above ground as preferred. The latter type is common if the climate is not very severe. The former is preferable if the filter is likely to be operated in very cold weather. When the filter is placed underground means must be provided for free circulation of air else it will become inoperative. In Fig. 127 an air space is constructed at one side of the bed and pipes are laid at the bottom to further assist in circulating air throughout the entire area. It is common to see sprinkling filters of this type working freely in severe weather with a ridge of ice and snow all around the margin of the bed outside of where the distributing head throws its spray, but perfectly free of ice within the circle.

Distribution may be effected in several ways. If there is sufficient fall from the septic tank to the filter a sprinkling head may be used. This, by breaking up the effluent from the tank into a fine spray as it is thrown over the surface of the bed assists the oxidizing process in a measure as the water is brought into intimate contact with the air. The sprinkler heads are set in the center of a small circular filter or at intervals in one of rectangular shape and larger size so that the spray is distributed equally over its surface.

An alternative method is to use tipping troughs. These are constructed as shown in Fig. 128. They operate simply and by reason of their shape. As the water flows from the siphon at the septic tank to the filter it fills the trough which is placed directly over the surface of the filter. As soon as the water level rises high enough the trough becomes top heavy and in consequence it falls to one side and tips the water over the surface of the filter. The action of emptying one side of the trough allows the other to come into the correct position to be filled and in consequence the action goes on indefinitely. The tipping first to one side and then the other is also advantageous as it allows the filter to be aerated between flushes.

Still another method is used. This cannot be adopted unless the septic tank is at a sufficient elevation to provide a little head in the outlet from the tank as the action of the distributer depends on this. In this system the bed is made circular in shape and the outlet from the tank comes up in the center of the bed. There is a circular track of T-iron laid around the outside edge of the bed and a carriage which supports a long water wheel is supplied with a small running wheel at one end resting on the track. The effluent from the septic tank enters a tipping trough placed on the top of the carriage and as this fills from the pipe forming the axle upon which the carriage revolves, the trough empties over on the buckets of the water wheel and this in turn causes the carriage to move around the bed. Thus the effluent is distributed equally over the entire surface and the power is provided automatically by the action of distribution.

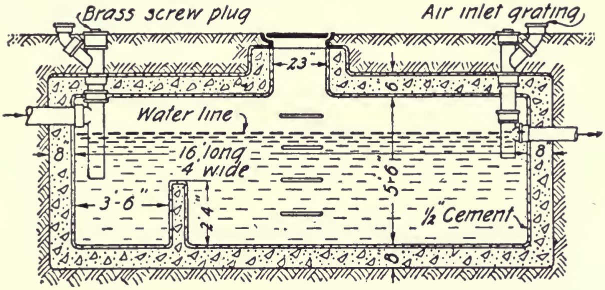


FIG. 125—SECTION THROUGH SEPTIC TANK

The effluent from a trickling filter may show a considerable amount of sediment but it is of a stable nature and if diluted with an equal volume of water may be disposed of without trouble. This type of filter however will not effect clarification enough, or sufficient certainty that a nuisance will not eventually be developed to permit of the flow being discharged on the surface of the ground or into a dry water course. Further filtration is necessary before that can be done with safety.

Clogging of Filters.

Contact filters are of an entirely different nature to those of the sprinkling type, although practically the same material may be used in their construction. Those found most efficacious are constructed of clinker or hard coke and the conditions to be aimed at are a maintenance of the large open spaces in the body of the material composing the filter, a material which will not crumble in use while presenting a not too smooth surface to the action of the sewage and as nearly uniform grading of the material as possible to mitigate the tendency to clogging where the material may be too closely packed. Sewage which has had most of the suspended matter removed by screening or by treatment in a settling or septic tank will be less likely to clog the filter and will afford a better effluent than raw sewage. Filters of this type are operated by filling them completely with sewage, allowing them to stand full for a short period, then draining and allowing them to stand empty for some time.

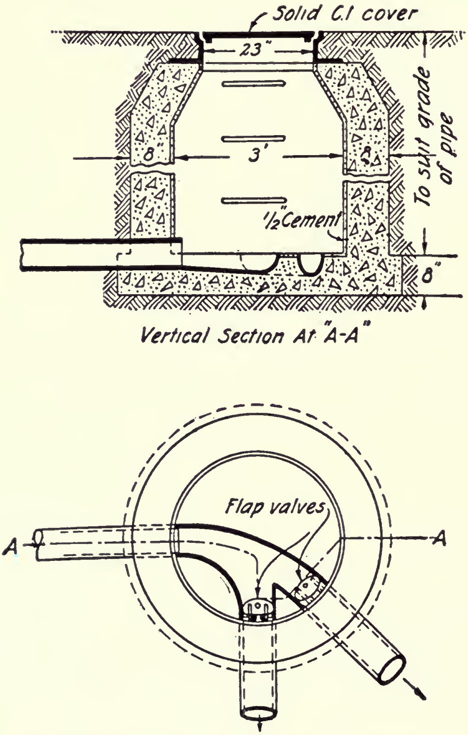


FIG. 126—DETAILS OF CATCH BASIN OR VALVE CHAMBER

The tests have shown that the best results are obtained by filling the contact bed once in 24 hours and allowing it to stand full one to three hours before draining. The bed may be filled either by intermittent doses such as can be applied by tipping troughs or filled at one operation by a siphon, the emptying may be accomplished in the latter manner.

The clogging of the filtering material will be more evenly distributed when the slow-filling method is adopted, as the rush of water from a siphon tends to carry the solids to the lower strata of the filter. On the other hand, some of the liquid will be in contact with the filter much longer than the rest when filled intermittently. The effluent from a contact filter usually contains considerable matter in suspension and may be much the same quality as that from a trickling filter, but unless carefully designed and operated the beds are likely to become clogged and the effluent of poor quality after they have been in use for a time. The chief advantage of the contact process for small installations is that it may be placed under ground, that it requires less operating head and that it may be made almost automatic in its various details.

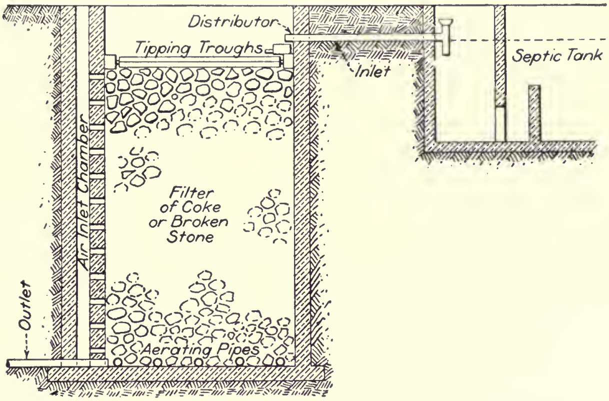


FIG. 127—A TRICKLING FILTER AND SEPTIC TANK SUITABLE FOR AN ORDINARY RESIDENCE

Intermittent Sand Filters.

The last type of filter is the common sand filter. This is simply a pit properly underdrained and filled with clean sharp sand to a depth of about 5 ft. as shown in Fig. 129. A very fine sand should not be used as unless the volume of sewage treated is very small the lower strata will become waterlogged and, owing to the inability of air to find its way through the mass, the nitrifying effect of the filter will be checked or entirely lost.

A sand filter cannot take care of such a large volume of sewage per acre as a contact or trickling filter and the best results have been obtained with a rate of flow of from 50,000 to 100,000 gallons per acre, as against 1,000,000 to 2,400,000 gallons per acre on a trickling filter and 400,000 to 800,000 gallons per acre on a contact filter.

The effluent, however, is much better, there is a large removal of organic matter, the inorganic matter is caught at the surface of the filter, where it may be removed periodically if necessary and a clear and inoffensive liquid fit to be discharged on the surface of the land or into any convenient watercourse is almost invariably obtained. The periods of dosing are not so easily regulated in a small system as in a large one, but the best results are obtained when the doses are applied at intervals of from 12 to 24 hours, while a rest of a few days to allow the filter to dry out and become thoroughly reaerated is desirable occasionally, the necessity being determined by the character of the sewage treated and the amount handled.

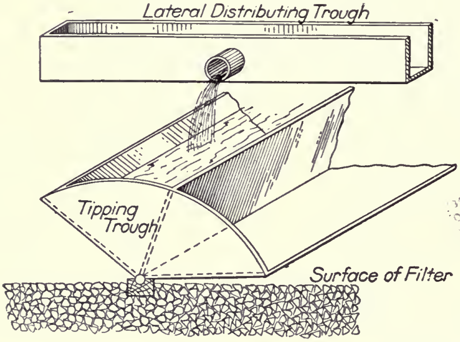


FIG. 128—TIPPING TROUGH FOR TRICKLING FILTERS

The degree of purification required must always be a factor in the selection of a type of purifying plant.

Where the sewage can be dicharged into a running stream subject to floods and in which water is at all times flowing, a purification sufficient only to insure that the effluents will not putrefy when exposed to the effects of warm weather is permissible and a trickling or contact filter will probably be satisfactory.

Where the discharge is to be made into a very small stream in which the turbidity of the effluent would be objectionable and in which there would not be sufficient dilution to prevent putrefaction a higher degree of purification must be effected. Trickling or contact filters with a further straining through sand, coke or coal may be recommended.

Where the highest degree of purification possible is required, as where the discharge is made into small streams that are occasionally dry, or where the discharge is made on the surface, sand filters with provision for previous straining or settlement should be adopted.

Should the installation be made in a district where irrigation is desirable the effluent from a septic tank may be put to good use for this purpose. Certain municipalities on the Pacific Slope have found it advantageous to dispose thus of the outflow from the city sewage disposal plants and profitable crops of hay and alfalfa have been raised on land previously of little worth through the aid of irrigation by the outflow from septic tanks.

Chemical precipitation of the solids is little practised in small plants although in some manufacturing plants the nature of the sewage is such that it is difficult to treat it in an ordinary tank. Where much acid or alkaline matter enters the drains the solids are often precipitated by chemical means and the sludge pressed and dried for disposal by burning.

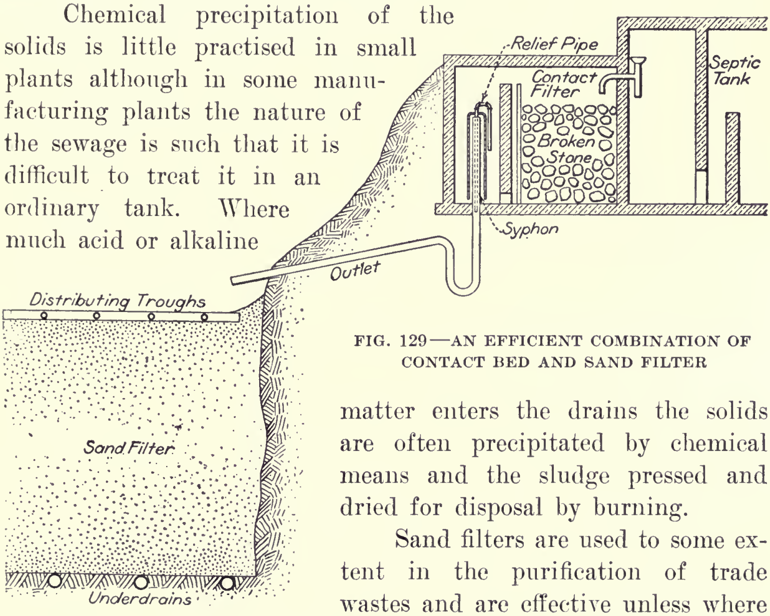


FIG. 129—AN EFFICIENT COMBINATION OF CONTACT BED AND SAND FILTER

Sand filters are used to some extent in the purification of trade wastes and are effective unless where the wastes are largely mixed with matter not conducive to bacterial action. These filters however remove much of the organic and other matter by the straining action and chemical precipitants enable the removal of the remainder so that a satisfactory effluent is produced. With some classes of trade wastes such as those produced in paper mills and glue factories the matt forming on the surface of the filter is tough and on drying out is easily rolled up like a carpet and removed for disposal by burning. Dyestuffs are also satisfactorily removed by sand filters, as much as 90 per cent of the coloring matter being removed by a well constructed and operated filter. Coke and broken stone filters are also used for this purpose with more or less success.

Wastes from creameries are difficult to handle owing to the liability to clogging the filters which the nature of the wastes entails but when sufficiently diluted with water satisfactory purification is effected by sand or coke filters.

The nature of the waste matter finding its way into the sewers in certain trades makes it worth while to recover a part of these and many processes are in use for this purpose. Among them may be mentioned the evaporation of the waste liquors from wool scouring and cloth washing establishments and the separation of fats from the water by centrifugal action, the recovery of fats by a naphtha process in establishments of the same nature, the recovery of lead chromate from paint works, etc.

The main function of sand and other filters therefore may be said to be to remove the dirt and mineral constituents of the sewage although bacterial action may be active in them at the same time.

CHAPTER XIII.

METHODS OF LAYING TILE AND IRON DRAINS FROM HOUSE TO SEWER OR OUTFALL AT SEPTIC TANK.

It is generally admitted that while tile pipe gives satisfactory service in conveying waste matters from the plumbing system to the sewer or point of disposal, it should not be laid inside of buildings. The reason for this is that the joints must of necessity be made of a material liable to fracture, and settlement of the building walls or of the soil upon which the tile pipe rests may cause the joints or hubs to break and so permit sewer air to enter the building. Therefore iron pipe should be used for that part of the drain inside the building in every instance and should be carried outside and connected to the tile pipe, if the latter is to be used, at a point at least 6 ft. from the outside wall.

In laying tile drains special care should be given to the grading of the ditch in which it is to lie. If the run is a long one the obstruction to the flow of water in the pipe may be sufficient to cause a gradual filling up by sediment deposited as the result of improper flushing if the grade of the drain is not practically constant. Sudden changes in direction or grade will cause part of the solid matter carried in the flow to be deposited and in time the deposit may result in a total stoppage.

Where it is necessary to change direction in a horizontal direction the bends used should be easy and should never have a radius of less than four diameters of the pipe. Thus, if a 4-in. pipe is used the bends upon it should have a radius of at least 16 in. Where a change in the grade is made necessary by the contour of the land it may be possible to effect it by the use of pipes which have been slightly bent in process of manufacture. As a rule these are plentiful enough and their use will aid considerably in reducing friction and resistance to the flow of water.

The effect of even one right angle bend on the velocity of flow in a tile drain is considerable and there is always some danger of deposits building up and eventually causing a stoppage when such are used. Much depends upon the amount of flushing water available in maintaining a satisfactory depth of flow in drains, but it may be said that if it is possible to grade the pipe so that there will be a velocity of some 3 ft. per second in the flow, the pipe will run somewhat over half full, and at that depth the greatest capacity of the drain will be reached. The reason for this is that the friction of the pipe at that depth is less in proportion to the "hydraulic radius" or effective head of water in the pipe than it is when full or less than half full. When a circular pipe is running some four-fifths full the maximum velocity of flow is obtained and at the same time solid matters conveyed are submerged and unlikely to cause obstruction by their weight resting on the invert.

To obtain these results it is necessary to secure a grade in 4-in. pipe of 1 in 53, for a 5-in. pipe 1 in 75, and for a 6-in. pipe 1 in 100. These figures are based on pipes of good quality and smooth bore with joints well made and free from projecting cement.

If it is necessary to lay drains at a gradient much less than these figures they should be as short as can possibly be arranged so that the velocity with which the discharge enters from the house pipes will in some measure balance the slower flow further on. The value of a large flush may be overrated unless the gradient is sufficient to maintain a proper velocity of flow in the drain to secure its full advantage.

When a body of water is discharged into a flat drain the crest of the wave rapidly becomes lower and a short distance from the point of entry it is lost and the flush becomes imperceptible. For these reasons it is desirable to maintain as steady a fall as possible from one end of the drain to the other.

In laying out the line of a drain, if proper instruments are not available an ordinary carpenter's level may be made to serve. It is first necessary to erect a station at a point over the sewer to which the drain is to be connected, or at the point of outfall. Then when the level has been set at any convenient height and the bubble of the level is in the center a sight should be taken to another station set up at a point 50 ft. away in the direction in which the drain is to run. On sighting on the station the necessary pitch is added. Probably 1 ft. will be available in the 50 ft., and this amount should be added to the height at this station. More stations should be set up at intervals along the line of the drain and lined up in accordance with the grade established from station *A* to station *B*. When the depth to which the drain must be carried at the sewer or outfall has been determined the distance below the established grade line at which the sewer or low point lies should be marked on a rod. Then it is easy to grade the bottom of the ditch so that a constant grade is obtained throughout.

In laying tile pipe it is well to lay a number of lengths together and to insert in each of the hubs a strand of rope yarn. This will prevent cement from finding its way into the interior of the pipe. The mortar used should be composed of 2 parts of sand to 3 of Portland cement and should be freshly mixed as required. If allowed to set and then worked over it will have a tendency to shrink away from the pipe and crack on setting. If no oakum is used in the joints a semi-circular piece of sheet rubber attached to a rod should be inserted and any loose mortar which may be pushed into the interior removed by drawing this disc to the end of the hub. If the cement is pushed in until the hub is almost filled and then is allowed to set, the joint may be finished to a bevel with the trowel later and a satisfactory joint which will prove permanent will result. In order to secure good alignment in the ditch and so aid the flow of water as much as possible it is well to stretch a chalk line and lay the pipe according to it.

If the soil in which the drain is laid is loose or wet there may be some risk of settlement, with the certainty that the joints will become leaky in a short time. In such conditions it is well to make some provision for the support of the pipe, and it is common to place under each pipe, at the hub, a brick or stone set in a foundation of concrete which will offer a greater support than the loose earth packed around the hub on refilling the ditch. It also makes access to the joints easier when the tile is being laid if the hub is kept up from the bottom of the ditch by a support of some kind, although where the bottom is hard and unlikely to settle at a later time, the tile may lie on the ground solidly and a part be scooped out at each hub.

If the drain is a long one or if changes in direction are frequent, it is well to provide cleanout openings. The best method of inserting these is to place a Y with the branch fitting looking up and to carry this branch to a point near the surface where a shallow brick pit may be prepared and a wood or iron cover placed over it. The end of the branch may be closed with cement or a lead disc set in red lead putty. The latter is the better way, as it is always possible to remove the disc and to replace it should access to the drain be necessary.

The same provisions that apply to tile pipe laying apply to iron, but with the latter material the longer lengths make the number of joints fewer and consequently the drain is, as a rule, more constant in grade and alignment. It is probably unnecessary to say that extra heavy pipe should be used for all underground work, and that the joints should be carefully calked. The bends used should be of an easy pattern and cleanouts should be provided wherever a change of direction is made. If these are placed in manholes or are carried to the surface with covers at the upper end of the branch pipe, as already described, access will be easily possible for cleaning when such is required.

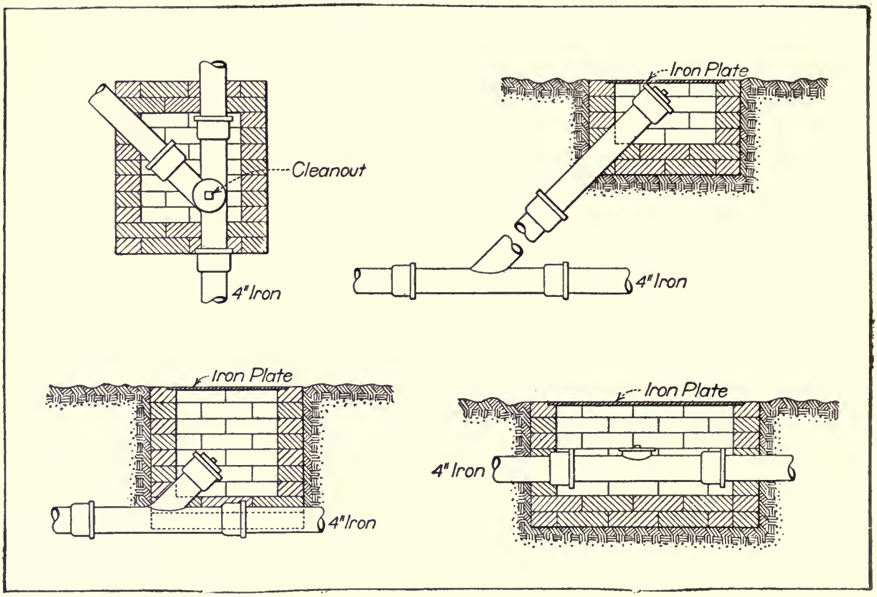


FIG. 130 FIG. 131
FIG. 132 FIG. 133

TYPES OF CLEANOUTS ON IRON PIPE DRAINS

Fig. 130—Special Y fitting with screw cleanout at junction. Fig. 131—Cleanout with extension from deep drain. Fig. 132—Cleanout calked into Y in brick pit where drain is near surface. Fig. 133—Special type of cleanout for insertion in long lines of drain near surface.

Access branches or bends may also be used, and if these are placed in brick-built or concrete manholes they may be on occasion convenient for access in clearing the drain of stoppages. Several different arrangements of cleanouts are shown in Figs. 130, 131, 132, 133 and 134.

When laying long stretches of iron drain pipes it is a good plan to calk several lengths together before they are put into the ditch. In order to do this with the greatest ease a number of blocks of wood cut with a V-shaped notch in them may be nailed on a long plank. If these are arranged as shown in Fig. 135 it is only necessary to place the pipes in position and make sure that the spigot end is firmly laid against the inside end in the hub before the joints are made, to be assured of good alignment. When the three lengths have been calked they can be placed in the ditch and at the point where the joint will be made a handhole should be cut to allow easy access in calking.

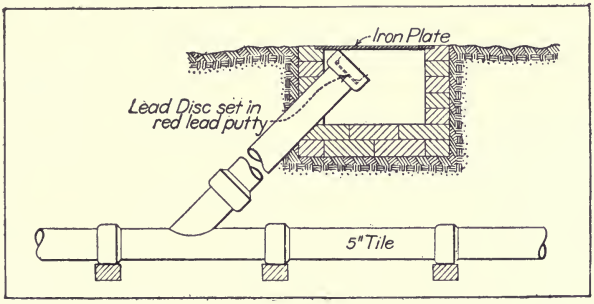


FIG. 134—CLEANOUT ON TILE WITH BRANCH EXTENDED TO SURFACE

If the ditch is wet and there is any danger of water finding its way into the joint after the oakum has been calked in, but before the lead has been poured, some oil or rosin should be put into the space left by the joint runner. This will be carried into the joint with the lead and will prevent steam forming and so blowing the molten lead back and possibly injuring the workman. Alternatively, lead wool can be used in place of molten lead with advantage.

To make sure that no obstruction is formed by oakum being pushed into the pipe at any of the joints in the ditch a candle should be put in through one of the inspection or cleanout openings, and if a mirror is held at the end of the line a view of the entire inner surface will be had.

The Danger of the Old Well.

It has been the practice in some localities to drain the wastes from plumbing fixtures in buildings into disused wells, in the belief apparently that in doing so the wastes referred to would filter harmlessly into the surrounding soil. Such belief is fallacious and there is real danger to the health of any community which permits such practices to continue. A leaching cesspool is a menace of much smaller proportions, bad enough though it be. The reason for the greater risk that is to be expected when waste organic matter is turned into an old well is obvious when it is brought to mind that the well would not have been possible had it not had direct connection with a body of underground water. The danger lies in that this underground water is not still, but is moving more or less quickly in the direction of lower levels and it may be that the pollution which it suffers through the seepage from old wells used in this fashion may have serious effects if the water is used for domestic purposes by others even at considerable distances. While the filtration afforded the water by its passage through the soil will remove much of the bacteria that the pollution of the water by sewage developed, nevertheless if it contained the germs of disease there is always the danger present that these will not be destroyed and may be communicated to others. Many cases are on record where the source of pollution of wells and springs has been proved to be hundreds of yards distant. When wells are disused through the adoption of modern systems of water supply and the adoption brings with it the general

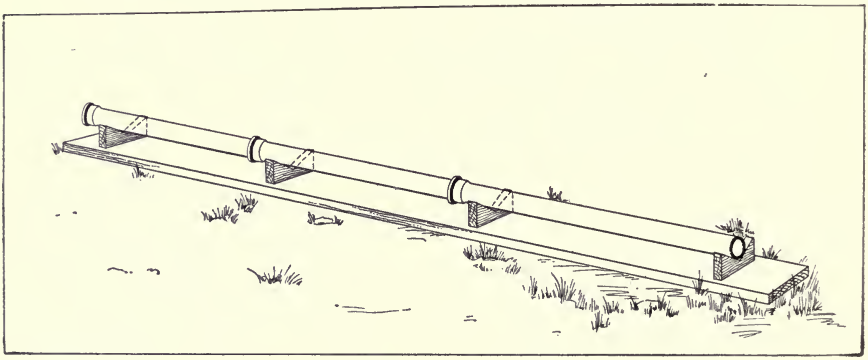


FIG. 135—CONVENIENT METHOD OF PUTTING LENGTHS OF IRON PIPE TOGETHER FOR LONG DRAIN LINES

use of modern plumbing equipment, proper arrangements should be made for the disposal of the waste, and as a precautionary measure all of the old wells should be filled. If no public system of sewerage is available for the reception of the wastes of the community, tight cesspools or septic tanks should be constructed and the outflow from these should be disposed of by a sub-surface irrigation system. This will distribute the matter where it will do the least harm and where the bacteria present in the upper layers of the soil will have an opportunity of breaking up the organic matters.

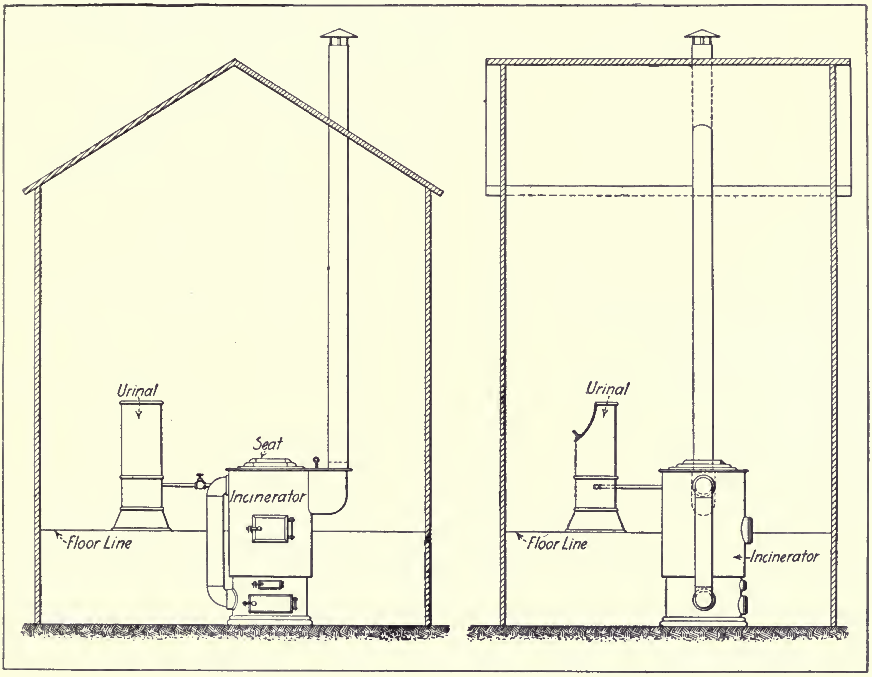


FIG. 136—GARBAGE AND REFUSE INCINERATOR

Sewage Disposal Without Sewers.

In situations where it is not possible to provide a water carriage system of waste disposal, organic and other matters may be disposed of by incineration. Such a system is of value for temporary camps, hospitals or toilets at resorts open for a limited period only and also for small bungalows and cottages where the installation of a proper system of plumbing and sewage disposal would be prohibitive in cost.

The type of incinerator shown in Fig. 136 is a convenient one. It is generally installed in a small outbuilding and includes a urinal as well as a garbage and waste incinerator. The floor of the building is raised a little above the ground so that a seat may be placed over the pan of the incinerator. Thus it may be used as a toilet as well as a receptacle for garbage. The incinerator consists of a cast-iron pan suspended over a firebox and covered with a tight fitting cover when incineration is in progress. The urinal discharges into a separate pan placed at a lower level than the garbage pan and the flues are constructed so that the hot gases must pass over each on their way to the smoke stack. The garbage is dried and the liquids evaporated by the hot gases and eventually the entire contents of both pans are destroyed. It is necessary to operate the incinerator once or twice a week according to the number of persons using the appliances and a range may be connected together with facility in which case the pans are placed over an extended firebox.

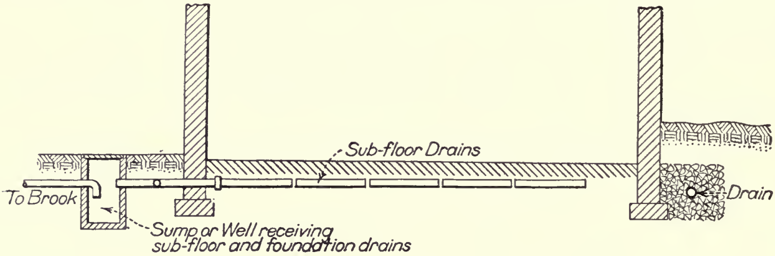


FIG. 137—METHOD OF DRAINING FOUNDATIONS

Another type of incinerator is intended for garbage burning only and is utilized principally as an adjunct to the water heating system although its principal object is to provide a tight receptacle for waste matters and a means of destroying them without odor or danger.

Drainage of Cellars and Surroundings of Buildings.

Where a building is situated at a low level and the ground water stands high, it is not uncommon to find the cellar of the buildings damp and unwholesome through the decomposition of organic and vegetable matters from various sources. Damp cellars are objectionable, no matter how well the building is constructed as the air passing up through the partitions conveys objectionable odors and causes a damp atmosphere throughout the building.

In order to avoid the evils attendant upon such undesirable conditions it is customary to provide a means of removing the water from under the floors and foundations of the building and this is done by one or more drains laid in such a manner as to provide an easy outlet for the water as it rises to the level at which they are laid. Sometimes it is a matter of great difficulty to secure a convenient outlet for this water. If the land upon which the house is situated is flat it may be impossible to secure a pitch to the sub-floor drains sufficient to admit of discharging the water to a point where it could be disposed of without risk of water backing up in times of flood and making the consequences worse than if no drains had been provided.

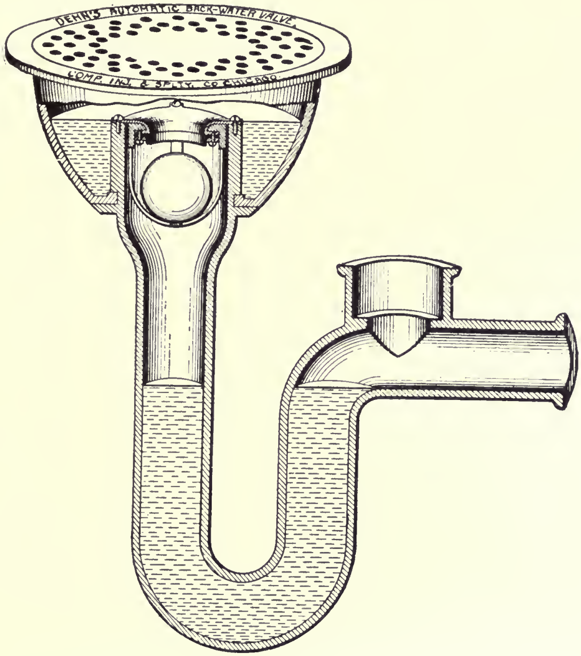

DEHN'S AUTOMATIC BACK-WATER VALVE
COMP. INJ. & SPLTY. CO. CHICAGO

FIG. 138—A BACK-WATER FLOOR TRAP

If on the other hand the building is situated on ground with a grade admitting of carrying the sub-drains to the surface of the ground at a point within reasonable distance of the building the problem is a simple one. In such a case it is only necessary to lay a series of tile drains with loose joints around the foundations and under the floor of the cellar, connecting them together and leading the tail drain to the desired point of outlet.

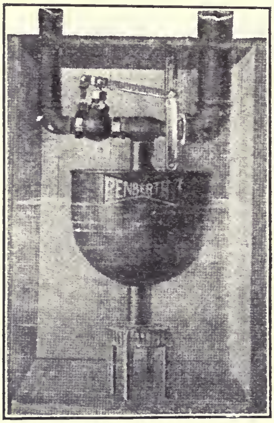


FIG. 139—AUTOMATIC CELLAR DRAINER

This may be done as shown in Fig. 137 where the drains under the cellar floor and from the ground immediately surrounding the building are led into a concrete sump or well and from there to a small brook at some distance from the If it is necessary to connect the outbuilding. let into a sewer more care must be taken in laying the drain. As there may be seasons when the ground water is very low for several months any trap provided to keep sewer air from entering the building through the sub-drains might become unsealed through evaporation. Such a trap would be placed between the sump and the sewer and in order to make it as safe as possible it is advisable to use a trap with a deep seal and an additional check in the shape of a ball or valve.

A trap of this kind is seen in Fig. 138. The ball acts to seal the trap at such times as the water is very low as it then falls to the lower seat. It also acts in the reverse way to prevent water from backing up into the ground beneath the floor should the sewer become flooded as then the ball floats to the high side of the float chamber and seats on the upper seat. This provision is an important one as where the liability to flooding of the sewer exists, the soil under the building and around it might become charged with sewage quite unknown to the occupants. For this reason, and to avoid the use of mechanical safeguards as much as possible it is always advisable to drain the ground to the surface when it is possible to do so.

When even the sewer is at such a height that it is impossible to carry the water away by gravity some simple and automatic method of raising the water to the sewer level must be provided. The simplest appliance is probably the ejector. This is operated by the pressure of the water in the supply system and comes into action through the raising of a float as the water level rises. In order to secure proper operation and a certainty that the ground water level will be kept down to a point safely below the floor level it is usual to provide a concrete pit several feet deep in which the ejector is set. The arrangement is shown in Fig. 139 which illustrates an ejector in common use. The arrangement and operation is as follows: The appliance consists of a valve operated by a float and a nozzle set so as to direct the stream passing through it into a chamber of such a shape as to induce a vacuum at the point where the jet leaves the nozzle.

CHAPTER XIV.

COLLECTION AND STORAGE OF RAIN WATER.

The proper collection and storage of rain water for laundry purposes entails the use of an underground or basement tank as a rule, although it is not uncommon to find the storage tank placed in the attic. The former, however, is the rule and the type of tank generaly used is a circular one built of brick or concrete. As the first flow of rain water coming from the roofs brings down a considerable quantity of soot and other impurities it is necessary to have some means of allowing this to go to waste. Therefore, a valve such as that shown in Fig. 140 is used. This is simply a Y made of galvanized iron pipe and intended to be inserted in the conductor pipe. The water passing down the pipe from the roof may be deflected to the side of the fitting leading to the surface of the ground or to a rain water sewer, or to the other side which is connected with the inlet to the rain water storage tank. After the rain has been falling for a short time these valves are turned by hand and when the rain ceases are turned back so as to deliver the first flow from the next rainfall to the waste outlet again. Automatic deflecting devices are also obtainable.

The cistern, when built underground, must be provided with a manhole so that easy access for cleaning is possible. Particles of organic and vegetable matter brought in with the water soon decay and as the oxygen in the water is used up the contents of the cistern becomes putrid. For this reason it is not advisable to build these of a size larger than is necessary to supply the absolute demand. If in a locality where water is scarce and accordingly rain water is highly prized, more elaborate means of maintaining it in a satisfactory state must be provided.

A means of aerating the water by the use of compressed air or a form of aerating pump which will bring the contents of the cistern into intimate contact with the air and so renew its oxygen contents will improve the quality to a great extent.

Filtration of Rain Water.

While filtration of rain water which has been stored for some time will not remove the odor which has been given it by the decomposition of organic and other impurities brought in by the first flow of water from roofs and gutters, it will remove the sediment at least and improve the quality so far. A filter may be constructed in connection with the storage tank and when this is done it generally takes the form of a smaller tank or a partitioned section of the storage tank through which the water is caused to pass. The filter is composed of gravel, sand, charcoal and occasionally, spongy iron. If the water is to pass down through the filter, by which method the best results are given, another chamber must be provided into which it can flow and from which it may be pumped or raised by a water lift.

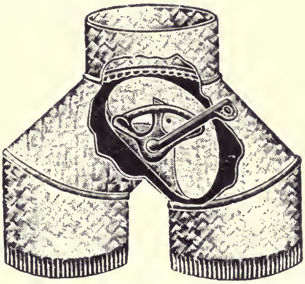


FIG. 140—RAIN WATER DEFLECTING VALVE

In this event the storage tank filter and well may be constructed as shown in Fig. 141. This calls for the construction of a rectangular tank with a brick partition separating the filter part from the storage part. The bottom of the filter is lower than the rest of the tank and about 3 in. from the bottom a ledge is provided for the support of a perforated plate to support the filtering material. Under this plate the pipe connecting with the pumping chamber enters and finishes with a regular strainer. On the plate is placed a bed of clean washed gravel about 5 in. deep, over which is placed a layer of coarse sand about 12 in. deep. Over this is a layer of charcoal about 4 in. deep and a top dressing of coarse sand about 3 in. deep. This latter should be raked off occasionally to remove the deposits which clog the interstices. The partition of brick between the storage tank and the filter is intended to allow water to percolate through it so that the joints need not be laid up in cement but if preferred the wall may be made practically water tight and pipes may be caused to connect with the filter chamber and the filtering material depended upon entirely for removal of sediment and other impurities.

Another arrangement may be made for filtering water from storage tanks as illustrated in Fig. 142. This is a cylinder which is attached to the suction pipe of the pump and which contains filtering material through which the water must pass as it is drawn. It has the advantage that it may be applied to any cistern and the filtering material may be renewed with comparative ease.

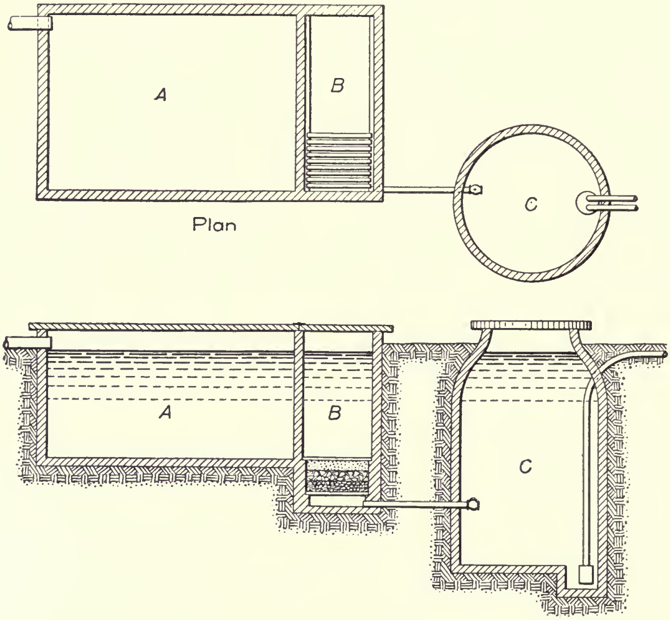


FIG. 141—RAIN WATER CISTERN AND FILTER

In order to raise the water to the fixtures an ordinary hand pump may be used or a water lift, operated by the pressure in the drinking water supply system, may be utilized. The latter is a small appliance operating on the same principle as a steam pump but using water pressure instead of steam pressure to drive it. It is connected to the rain water tank by means of a suction pipe and to the pressure water supply system by the pipe leading to the driving end of the pump cylinder. It operates as follows:

When a faucet on the soft water system is opened and the pressure is reduced in consequence, a diaphragm valve on the city water supply admits water to the driving end of the water lift. It immediately starts pumping and operates until the pressure at which the system is designed to operate is regained. A compression tank fitted immediately over the water lift is of material advantage in maintaining a steady pressure and also in providing a good flow of water. A pressure heavier than that necessary to raise water to the highest fixtures may be maintained in the tank so that when the faucet is opened water is delivered in a full stream while the pump will be able to maintain a supply sufficient to compensate for the reduction in pressure as well as to raise the pressure in the tank to the desired point when the faucet is closed again. In effect a small pneumatic water-supply system is installed when this method of fitting the water lift is adopted. The illustration in Fig. 143 shows a typical installation.

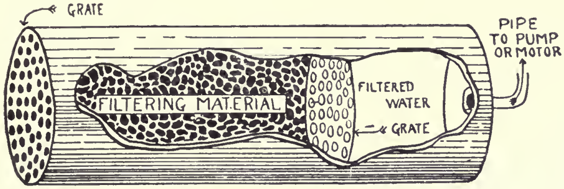


FIG. 142—ARRANGEMENT FOR FILTERING RAIN WATER

Lining Tanks With Copper or Lead.

The metals ordinarily used for the lining of tanks for the storage of water are copper or lead. The first metal is most commonly used as it is lighter, easier to handle and gives long service when properly fitted. The weight and size of the sheets used depend on the size of the tank to a great extent but in any case it is not good practice to use lighter than 16-oz. copper. The sheets should be tinned on the inside so that there will be no contamination of the water by verdigris which may form through the exposure of the metal to dampness.

The method of lining a tank also depends upon the size, as where a large tank is to be handled it may be advantageous to use the larger sized sheets. In order to illustrate the method commonly used it may be assumed that a tank 1 ft. 6 in. deep, 3 ft. wide and 4 ft. long is to be lined with sheets 24 in. wide and 4 ft. long. These would be tinned on one or both sides as might be required.

In Fig. 144 is illustrated the pattern of the lining prepared for the sides in the first method. In Fig. 144 the sheets have been first squared up and cut the necessary width, which in this case means only trimming, and the edges of the sheet tinned about an inch wide on both sides and at the two ends for soldering. When washed clean they are seamed together similar to continuous roofing and made the length required. Now examine Fig. 144 and suppose the sheet ABCD shown there to represent the lining of the tank. Find the middle, NK. Now mark off with a slate pencil or a chalk line the end FG, making it from F to G 2 ft. 11¾ in.; then the two sides EF and HG, making them 3 ft. 11¾ in., thus allowing ¼ in. for the thickness of the sheet and the turn of the corner, which cannot be turned sharp enough to go quite close up into the corner. Mark off the two halves of the other end, AE and CH, each one-half of FG, and leave on enough for the seam; then notch the side intended for the bottom, as at B and D, and fold the ends ready for the seam. Next strike the line MO, making the distance OD and MB 4⅛ in.

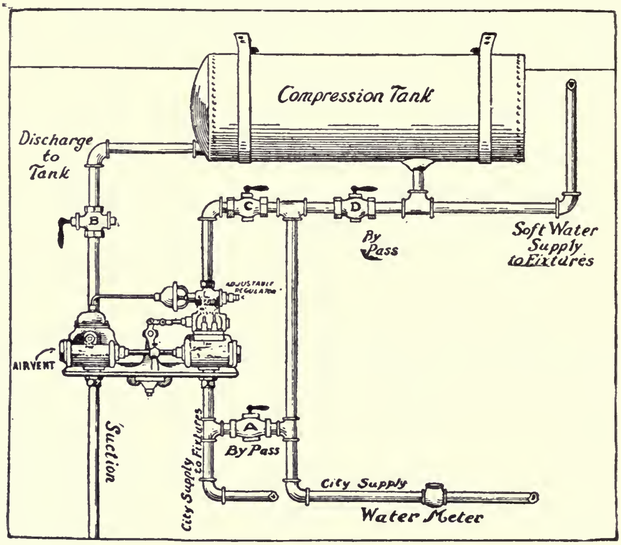


FIG. 143—METHOD OF INSTALLING WATER-LIFT

Take a level set at an angle of 45 degrees and lay it on the line MO at the points L and P and mark the lines PU, PS, LV, LT, leaving on the sides SP and LT, say, 1¼ in. for underlap at the corners, and the same at I and R. Clean and tin the return or bottom edge, both sides, with a suitable soldering copper, and when cool enough wash off the acid used with a wet wisp and clean water, and then dry it. Now, if a suitable pair of roofing tongs are at hand, lay the metal on the floor and with the tongs turn up the return for the two sides and the middle end or lay a piece of studding or any suitable piece of timber at hand on it at the line, and pull sides and end up square and dress them true with a mallet. Bend the corners square, lock the seam and knock it down close; then solder it down within 2 in. of the bottom edge, keeping the sides in shape with two crosses (╳) made of 6-in. board nailed together in such a way as to hold the sides in shape while the work of making the seam is going on.

When completed make the return here to correspond with the other end and two sides, and knock the corners smooth and a little round so they will not catch in the angle of the wooden side as it is let down into its place. Put the sides into the tank, and when it is down in its place and properly fitted, nail through the underlap at the corners with copper nails if at hand; if not, with the next most suitable for the purpose.

To prepare the bottom, turn up an edge on the return about ¾ in. deep with a pair of roofing tongs and then a similar edge on the bottom ½ in. wide and make it fit snug in and up to the edge of the return edge. Examine the work now closely, and if the bottom fits suitably to proceed, turn the return edge (which is ¼ in. wide) down over the edge of the bottom similar to the standing seam of a roof and close the edge smooth all round and notch the corners. Now take a

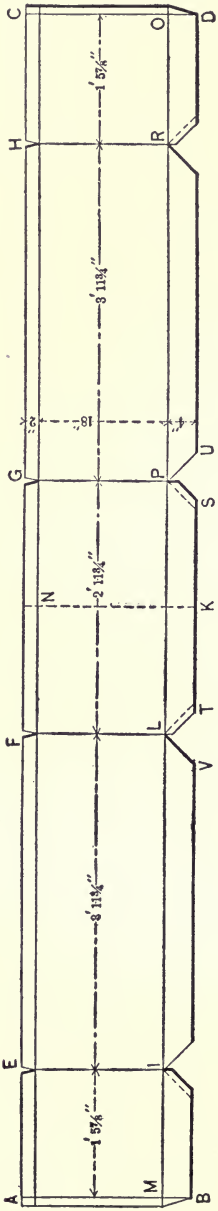


FIG. 144—PATTERN FOR TANK LINING PREPARED BY FIRST METHOD

hatchet stake and lay the blade flat on the bottom, and with a mallet bring the seam over on the blade all round, after which the seam may be closed down on the bottom and smoothed for soldering. The soldering may be done with the ordinary tinner's soldering coppers of sufficient capacity. If it is not desirable to seam the bottom in, then nail the return edge at suitable intervals so that there be no buckle, and lay the bottom in place, nailing between the under nails and letting the bottom lap, say, 1 in. all round. This also may be soldered in the ordinary way.

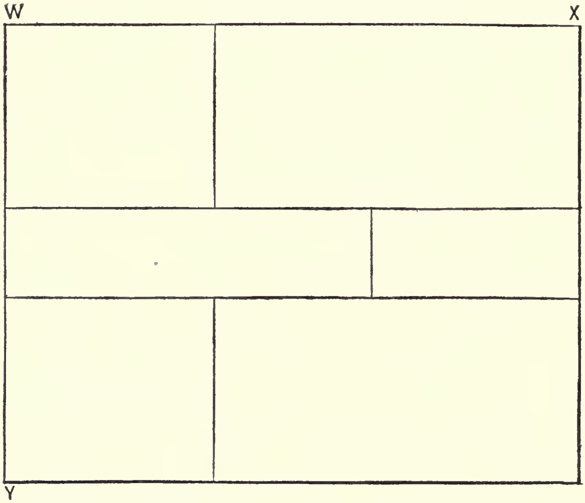


FIG. 145—SHOWING HOW SHEETS LIE TOGETHER

Second Method.

In Figs. 145 and 146 is illustrated a second method of preparing the sheets, in which the lining is finished at the two ends of the tank. Examine Fig. 145 and notice the way the sheets lie together. WXZY is the same size as MNPO in Fig. 146. Now having all the sheets seamed together and made the size required, as in MNPO, Fig. 146, line out the pattern and proceed as follows: First square the metal, and draw the center line QR, and from Q and R measure off each way QA and QB, 1 ft. 5⅞ in., thus deducting ⅛ in. each side for the thickness of the sheet and the turn of the corner, and making the distance, AB and CD 2 ft.

11¾ in. Now mark off HA and BG, and EC and DF, making them 17⅞ in., and from FS and GT 2 in., and at EU and HV 2 in. From M and N mark off 6 in., NS and ME, on NT and MH, and draw the line ES. From O and P mark off 6 in., PT and OH, on PS and OE, and draw the line TH. Then take a bevel set at an angle of 45 degrees and lay it on the line ES at the points C and D, and mark the lines YC, and CW, and X′D, DZ′, leaving on CW and DX′ about 1¼ in., as shown by the dotted lines 2 3 and 4 5 for underlap at the corners (for soldering). Next line off the corners IAK, JBL, at the other end OP the same way, and cut out with the hand shears the gusset pieces Y 23, Z′ 54, I 89 and L 67. The sheet may then be formed up in the way before directed, and the ends seamed in the same manner as described for the bottom in the first method, the tank being turned on its side, and soldered with soldering coppers in the usual way.

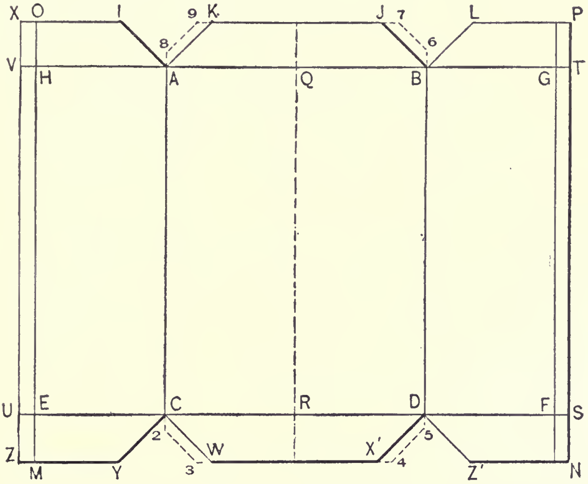


FIG. 146—PATTERN FOR LINING PREPARED BY SECOND METHOD

In the foregoing it is supposed that the work would be done in the shop, where the tanks could be manipulated as required to suit the work. But if the cistern be a fixture and there be room adjacent to the cistern, prepare the metal on the floor in a similar way as before described; if there is no room, then proceed as circumstances dictate, using the best judgment to save time and labor. When the lining is all in proceed to solder the upright seams as follows: Take some good soldering acid and with a brush apply the acid to the joint to be soldered. Be particular to have the soldering copper clean by frequently dipping the point in a jar of sal-ammoniac and water, and have the nose nicely tinned on all four sides. With a stick of good fine solder begin at the bottom, placing the solder against the seam, and with the copper bite off a drop of solder, which will hang to the soldering bit and transfer it to the seam; then bite off another drop of solder and carry it to the seam in the same way just above the other, and proceed in this way little by little until the top is reached, doing an ⅛ to a ¼ in. at a time. Perfection in soldering upright seams can only be acquired by patience and practice. The ability to do this kind of soldering work lies in being able to carry the solder from the stick to the seam in such a manner that it will look like Fig. 147 when finished, which can soon be attained by the proper effort and perseverance. When all the upright seams are done proceed with the bottom. Examine closely to see that every part of the joint has been tinned properly and covered with solder. When the joint is finished, wash it off with a clean wisp and clean water, then dry it.

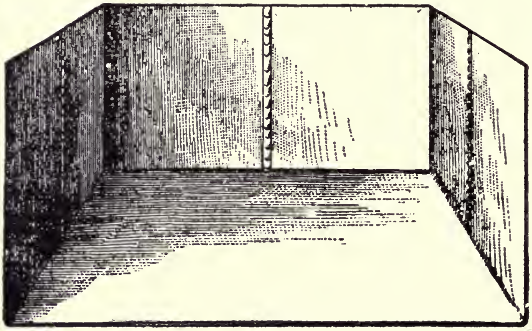


FIG. 147—INTERIOR OF TANK SHOWING SOLDERED SEAMS

Wiping Seams.

Wiping seams requires practice. If the tank be a fixture and large, say 18 in. deep, as in the first case, the side and bottom of the tank must be grooved or channeled out where the seams come, say about ½ in. deep and 1½ in. wide as in Fig. 148. First lay the bottom, and let the channel be at least 6 in. from the side (never get the seams in a corner closer than 6 in. if it can be avoided), and contrive to get the upright seams where they can be got at easily. Lay one edge of the seam right over the channel and sink it in and tack it at the two ends and in the middle, and then lay the edge of the next sheet in the middle of the channel and tack it to its place with copper tacks, as in K and M. NO shows a section of the bottom and K and M shows how the bottom and sides come together; BEFD shows the bottom seam, and HG a side seam.

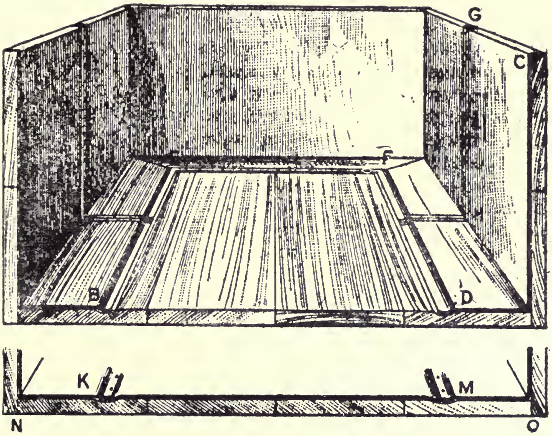


FIG. 148—TANK LINED AND SEAMS PREPARED FOR WIPING

After all of the seams have been carefully tacked the tank should be swept perfectly free of dust and strips of paper should then be pasted along each side of the seam so that the solder will not take hold of the metal at any other part than at the seams. Then a little tallow may be rubbed along the seams and the solder got ready for the wiping operation.

The vertical seams corresponding to HG would be wiped first. To accomplish this it is necessary to apply the solder at the top of the seam with a pouring stick or splash stick. The solder should be heated to a good working heat before commencing to pour it on the seam and in addition there should be at hand a tank iron, heated to a red heat and with all scale filed off.

When pouring is commenced it will be found easier to use a wiping cloth to pour against so as to direct the solder against the seam. As the solder flows down it is pressed into the hollow. The first of the solder will stick fast but as the heat takes effect it will flow to the bottom of the seam and it is necessary to keep raising it. When the whole mass is in a semi-molten condition, the ladle should be dropped and the tank iron taken up. It is run rapidly up and down the seam, pressing lightly on the solder and then the wiping cloth is taken with two fingers slightly apart and the solder patted into the seam at the top of the tank. Then the seam is wiped smoothly down to the bottom, using the iron to melt any particles which have set on the edges and patting the solder in meanwhile so that the finished seam will be flush with the inside of the tank.

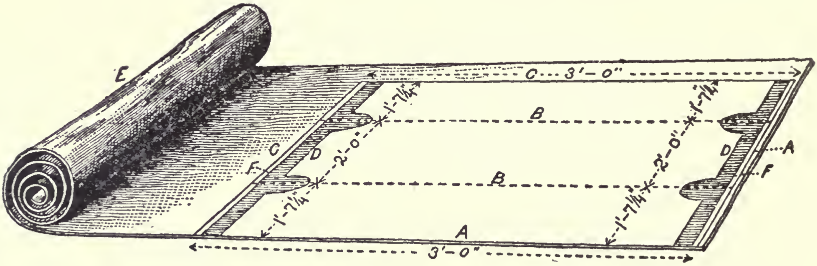


FIG. 149—SHEET READY FOR CUTTING

The joint with the seam in the bottom of the tank should be wiped a little way on either side and the rest of the vertical seams finished before the bottom one is begun.

The wiping of the bottom seam offers little difficulty to one acquainted with the working of solder. It consists merely of pouring on solder until about 3 ft. of the seam is filled with molten solder hot enough to flow freely. Then the wiping cloth is used to draw the solder along, patting it down so that the seam will be properly filled and the surface of the wiping flush and smooth. The tank iron may be applied as often as necessary to keep the solder flowing freely and at the junction with the vertical seams care should be taken not to run the hot solder too far in to the sides of the tank as it will be difficult to make a neat appearing finish if the vertical joint is melted at this stage.

When the bottom seam has been wiped all around the finish is made by flicking the superfluous metal to one side. After it has cooled the paper used to prevent the metal spreading should be washed off and the lining smoothly dressed as it will have bulged up some through the action of the heat on the sheets.

Lining a Tank With Sheet Lead.

If the tank to be lined is not of very large size the best method to use is to cut out the body part, consisting of the bottom and two sides from the sheet in one piece. In Fig. 149 is indicated the method of cutting such a piece for a tank measuring 2 ft. x 3 ft. and 1 ft. 6 in. deep. In this case the wooden tank is 1¼ in. in thickness, therefore, the sides of the lining are kept 1 ft. 7¼ in. deep so that the lead will turn over the top of the tank to make a neat finish.

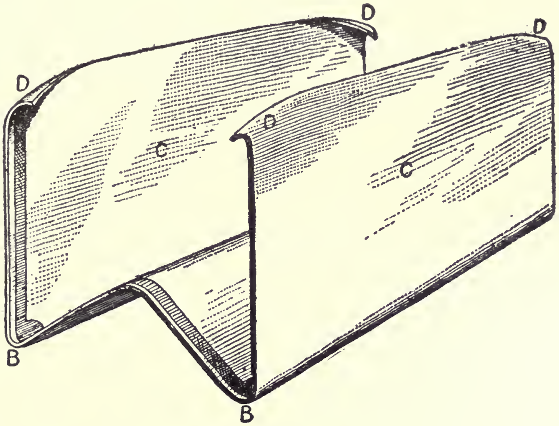


FIG. 150—SHEET BENT UP READY TO PUT INTO PLACE

The lead should be carefully squared as it is necessary that it fit the tank closely. The lines of the bottom should be marked on the lead with chalk and after the edges have been squared the ends should be soiled and shaved to a height of about ⅞ in., as indicated in Fig. 149. Then the shaved parts should be covered with tallow to prevent them from tarnishing until it is desired to wipe the seams and the lining is ready to be set up at the marks already indicated by BB.

When these marks have been followed with the edge of the dresser, tapping slightly with a hammer, meantime, the lead will bend squarely up and may be dressed as sharply as is necessary to make a good fit in the tank. Then the lead should be bulged up in the center of the bottom as indicated in Fig. 150 so that it may be dropped into the tank without binding against the sides.

When the lead is into position in the tank the bulge is dressed back and finished smoothly with the mace or flap shown in Fig. 151, and which consists simply of a piece of lead bent into a convenient shape as shown.

The type of dresser best suited for lead work is indicated in Fig 152. The sharp nose may be used to get the edges of the lead sheets fitted closely to the angles in the tank, after which tinned tacks should be driven in at about two inches spacing all along the angles. Then the ends are prepared to fit and are shaved all around to a depth of 7/8 in. before being put into and tacked in place in the tank. When this is done the tank is ready for wiping.

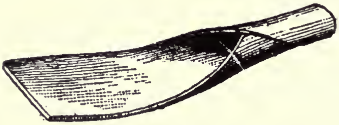


FIG. 151—LEAD MACE

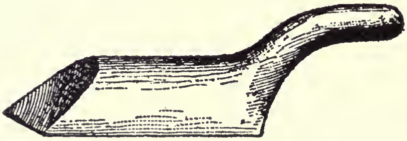


FIG. 152—WOODEN DRESSER

The wiping of the seams requires some skill but does not offer great difficulty to a plumber experienced in handling solder.

The amount of solder required in wiping the seams depends on the length and it is also necessary to have one or more tank irons to maintain the heat while wiping them. Alternatively a torch may be used for this purpose, but this requires careful handling to avoid burning the lead. Wiping should be begun at the top of the seam and should proceed downward to the lower corner, then across the bottom about half way.

The seam in the other corner should then be wiped in a similar manner down toward the angle and across to the part where the first wiping was left off and finished there. If the tank is a large one, the sides and ends may require extra support to prevent bagging and this is done by making small depressions where necessary, pressing the lead back into them, shaving and then fastening by screws. After that the depression is filled by wiping it flush with solder. When a tank of large size is to be lined it may be more convenient to put the bottom in separately. When this is done it is well to use lead of greater thickness for the bottom and never less than 7 lb. to the square foot should be used, with 6 lb. lead for the walls. No more difficulty is experienced in wiping the seams of large tanks than in small ones, but it is important that a large amount of wiping solder and several tank irons be at hand when the operation is attempted.

If the tank is stayed by lateral braces across the center these should be covered with lead pipe. It is seldom that rods of more than $5/8$ in. in diameter are required as braces and these may be covered with light-weight $3/4$-in. pipe, with flange joints to the tank lining at either side.

Connections to lead tanks should invariably be made by wiped joints. If it is desired that the connection be flush with the bottom there should be a countersink made around the hole before the lining is put in, or the lead may be raised temporarily while the wood is being countersunk and then dressed down into the depression.

CHAPTER XV.

COVERING SINK DRIP BOARDS WITH SHEET METAL.

Although the use of sinks with wooden drip boards is not now so common as it was a few years ago, owing to the introduction of porcelain and enamelled iron ware, many architects still specify the style of pantry or kitchen sink on which it is required that metal-covered drip boards shall be provided. This is called for principally because the soft metal with which they are covered is less likely to break glass dishes which are accidentally brought in contact with it when washing, and if it is carefully put on, a very neat and sanitary job may be secured. The metals commonly used for this purpose are zinc, Britannia metal, block tin, and sheet lead.

The first is the cheapest and the hardest to lay properly, but if well laid and kept free from grease afterwards, it offers a serviceable covering which will answer the purpose admirably. Britannia metal or block tin are far and away the most attractive coverings that can be used and either will stand long and hard usage without losing its appearance, but the block tin is expensive and its use accordingly is restricted. It, however, is probably the cheapest in the end, as it is soft enough to admit of much careless handling of glasses with little damage to them and yet hard enough to withstand damage to the covering from that careless usage. Its appearance is also very attractive as it keeps a bright and silvery appearance for years.

Sheet lead is a metal that can be used with good effect in most cases and it has the advantage that it can be worked into corners and around beads and angles without the need of solder at the joints, as is necessary with harder metals, and thus a smooth job with little opportunity to collect dirt at the joints and corners is secured. It is also soft enough to be desirable for a covering for pantry sinks where much glass ware is handled, but is more difficult to keep in an attractive state than either zinc or block tin.

If lead or zinc is allowed to remain damp for any length of time they become oxidized and the white skin that forms on their surfaces causes the covering to appear dirty and unattractive. If the cover is kept free from grease and is dried off by the user each time dishes are drained on the boards this coating will not form and the metal will keep its bright and smooth appearance for an indefinite time. This is the only objection that can be urged against either metal and it is one that need not be considered a disadvantage in many respects as it calls for the maintenance of a thorough state of cleanliness at all times.

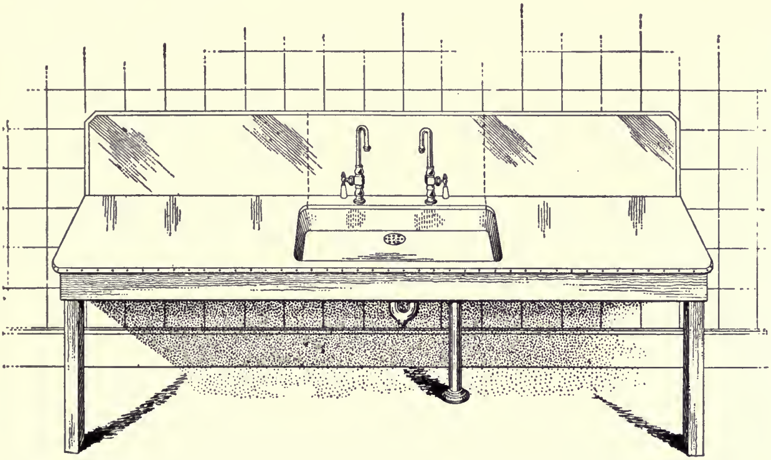


FIG. 153—VIEW OF PANTRY SINK WITH DRIP BOARDS COVERED WITH ZINC OR BRITANNIA METAL

Each of the metals calls for a certain amount of skill to get the best results from it and each requires a little study to make a neat job. Thus, if a sink top similar to that shown in the accompanying illustration, Fig. 153, were to be covered with zinc, the sheets would be cut differently than if it were to be covered with lead or block tin. In the first place, the zinc is hard and could not be worked over the round corners of the sink or the rounded edges of the drip board as lead or tin could. Therefore, the joints must be made in the covering and these should be arranged so that they will offer as little opportunity for the collection of dirt as possible and also so that they will be in a position admitting of making a smooth and neat job.

In Fig. 154 the method of cutting out the zinc is indicated so as to secure as few joints as possible and also so as to require as little cutting into the sheets as can be arranged. In this case where a sink 30 in. long and 18 in. wide is to be fitted the top will be 23 in. wide if an allowance of 2½ in. is made for the cope at the front and back of the sink. If 1 in. is allowed for covering the front of the top, that will leave 12 in. to be used as upstand at the back. This is sufficient to protect the wall against splashing from the sink and uses up the full width of the 36-in. zinc sheet.

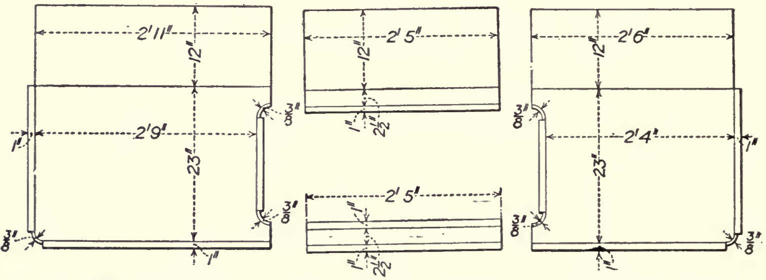


FIG. 154—METHOD OF CUTTING ZINC FROM ONE SHEET TO COVER DRIP BOARDS OF PANTRY SINK

If it is desired to make a top that will have ample room for all ordinary purposes and that will yet be of such a size as to be economically covered, it will be well to make one end of the top 2 ft. 9 in. long and the other 2 ft. 4 in. long. This will allow of all of the covering being cut from one sheet of zinc 3 ft. × 8 ft.

The best place at which to make the joints so as to allow of turning the zinc down 1 in. inside the sink is indicated by dotted lines in Fig. 153. This calls for a little manipulation of the zinc at the rounded corner of the sink, but in Fig. 154 it will be seen that the metal is cut so that the 1-in. lap is allowed for on the straight part, but only ⅜ in. on the rounded part. This ⅜ in. is intended to be worked down to form a neat round corner, and a strip of zinc can be soldered in to complete the lap. One inch is allowed at the front turning down over the woodwork and 12 in. at the back for an upstand.

The part covering the cope at the front of the sink is 4½ in. wide and the part that forms the upstand and covering for the cope at back of the sink is 15½ in. wide. This allows of 1 in. turning down into the sink at the back. The length of these parts is 2 ft. 5 in. and this is sufficient to admit of a good lap at the seams.

When the zinc is being prepared the first thing to do is to roll it out and turn the sheet over. Then the corners should be bent upward and the tendency to roll up taken out by rubbing the sheet toward the center. This will cause the sheet to lie flat and so permit it to be worked easier. Then the measurements should be laid off, drawing a line 12 in. from the edge for the back up stand. The sheet should then be cut into three parts, one 3 ft. long, one 2 ft. 5 in. long and one 2 ft. 7 in. long.

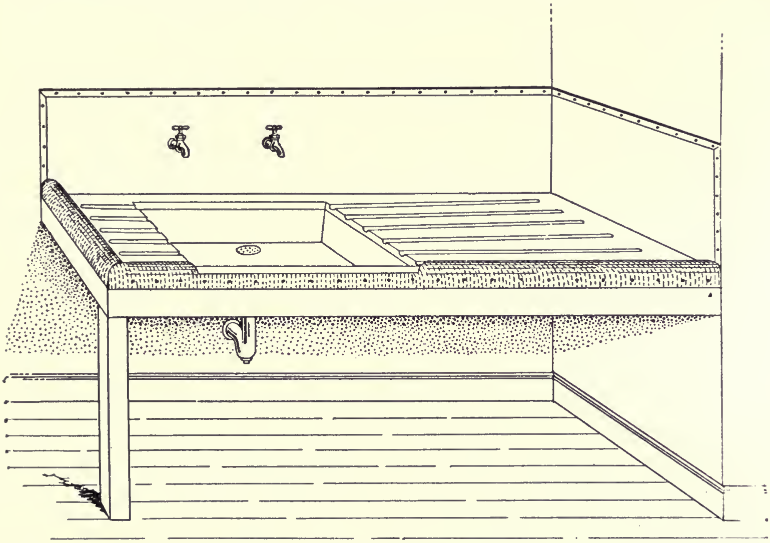


FIG. 155—VIEW OF PANTRY SINK WITH DRIP BOARDS COVERED WITH SHEET LEAD

The first and third sheets should be notched as shown in Fig. 154 for the parts that are to turn down over the front and ends of the sink boards, leaving at the corners the rounded part that is necessary to beat over the corner 3/8 in. deep. The shape of this may be taken from the drain board with a piece of cardboard and transferred to the zinc. The shape of the sink should be found in the same way and the part that is to be cut out scribed from the template. Then an allowance of 1 in. should be made inside the mark and at the point where the line takes the turn the lap may be reduced to 3/8 in., as shown in Fig. 154.

The sheets after being cut out to the correct sizes should be taken to a bench with a plate of iron screwed to it, or a good board of hardwood with a sharp edge may be used. There it should be set up and dressed smoothly at the angles. The part that is to turn down at the rounded corners should be dressed gently down with a mallet or a round peen hammer, warming the zinc a little as it is being done.

The parts forming the cope and the back should be placed in position first and it will be well to get the position of the holes for the supply cocks and to cut the holes for them before placing the zinc in position and finally nailing it. When the piece is ready it should be tacked into its position at the upper edge of the back part and at each end of the cope so that it will fit closely all round. To insure a close fit to the sink the zinc should be dressed a little past the right angle and the edge "broken" or bent slightly inward so as to clasp the inside surface of the sink firmly when it is pushed down into its place.

Then the two end parts should be put into place, and these also should be tacked along the upper edges and at the front of the board. They should not be tacked around the inside lap of the sink or in the part where the seam is. It will be well to see that the zinc is lying close to the inner surface of the sink before any nails are put in. If all is fitting closely the covering may be tacked at intervals of about 1 in. all round the top edge of the upstand and along the front edge and ends of the drain boards. Then strips of zinc are introduced at the rounded corners of the sink and drain boards and the seams are smoothly soldered.

A neat finish will be secured if the upstand is finished with a bead of hardwood or brass. If brass is used, the D-shaped pattern should be selected and it should be fastened by screws with round heads, or if flat head screws are used the holes should be countersunk. The seam after soldering should be scraped clean and finished with a piece of emery cloth if necessary, but care should at least be taken that there are no projecting points or edges not clasping the inside of the sink properly, as then there will be a possibility of dirt lodging and forming a nuisance.

If the same top were to be covered with Britannia metal or block tin the sheet could be cut out in the same way or it could be put on all in one piece if desired. In the first method it would not be necessary to notch the corners so as to allow only 3/8 in. to turn down into the sink as the metal works easily and the full 1-in. lap can be turned down without trouble. If a sheet of metal large enough to cover the whole top is procurable, that is the best for the purpose. Then all that is necessary is to scribe the outline of the sink at the position on the sheet it will occupy and cut out this part after allowing a sufficient margin for lap into the sink.

It is well to allow a little more than 1 in. in this case so that the edge may be trimmed down after the covering is into place and smoothly worked down. The way to proceed in using this metal is to secure a smooth place on which to lay the sheet and then the unevennesses are taken out by rubbing the sheet with a smooth dresser or a piece of soft wood. The upstand for the back is then set up, using a board to bend the metal sharply over and seeing that the corner is neatly made. The sheet is then placed upon the top of the sink and temporarily secured by tacking.

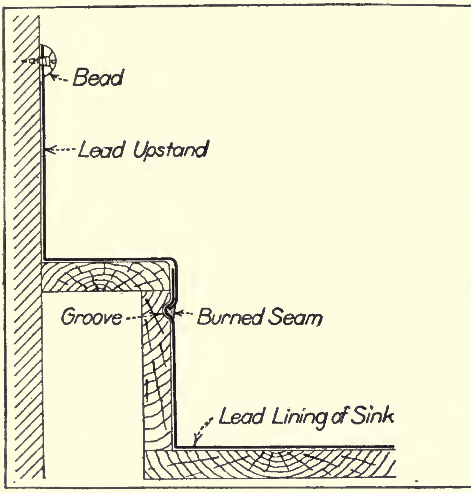


FIG. 156—METHOD OF MAKING SEAM BETWEEN COVERING AND SINK LINING

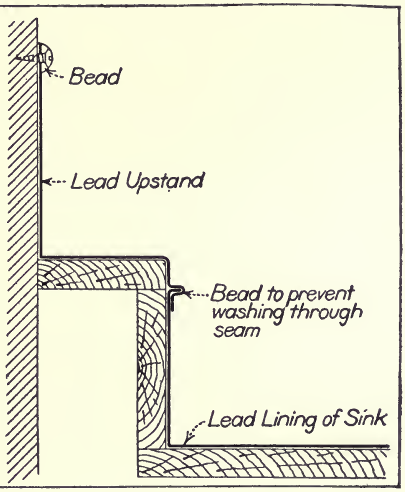


FIG. 157—A SEAM DESIGNED TO PREVENT LEAKAGE BACK TO WOODWORK

After making sure that the sheet fits closely at the back, the work of forming the metal down into the sink is begun. This is done entirely by rubbing. A round steel pin or a round dresser of hardwood is used for this purpose, and by rubbing slowly and equally along the overlap the metal is caused to turn down into the sink the required amount. The corners require careful handling to prevent thinning and tearing. If the rubbing motion is made in such a way that it will tend to drive the metal into the corners the thickness will be better maintained and there will be correspondingly less chance of tearing at that point.

The part turning over the front is bent over in the same way and the rounded corners are covered by rubbing the metal down. After the whole piece is fitted closely it may be smoothed down by going over it with a flat iron which has been heated to a moderate temperature, and then the edges should be tacked at points about 1 in. apart with brass escutcheon pins about 1 in. long. If it is necessary to solder the metal at any point care must be taken and a well tinned iron of moderate heat should be used. Rosin should be used as a flux and the solder applied very carefully.

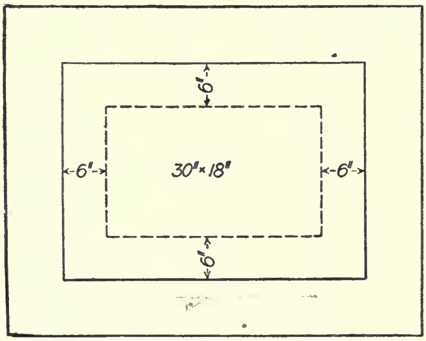


FIG. 158—METHOD OF CUTTING OUT LEAD FOR SINK LINING

It is easier to solder this metal when a fine solder run out into thin sticks is used. The upstand may be finished with a wooden or brass bead, as described for the zinc covering, or the tin may be worked over the bead.

If it is desired also, a wooden upstand bead can be nailed around the front and ends of the drip board so as to prevent any water from running over the edge. This should be rounded on the top and should stand above the level of the board about ½ in. The metal is simply rubbed down into its seat and then rubbed over the front of the bead. By this means a very neat finish is given to the board.

Grooves run in the wooden top and then followed by a dresser in rubbing the tin down flat help to drain the water away from dishes laid on the surface quicker, and these are very easily made. They should measure about ¾ in. wide at the sink and gradually taper until they disappear at the end of the board. This gives them sufficient pitch to drain quickly.

How to Cut and Fit Sheet Lead on Drip Trays or Boards at Pantry Sinks—Beating the Metal Into Position and Method of Covering by One or More Pieces.

Lead is applied in the same manner as Britannia metal or block tin, with the exception that it may be dressed instead of rubbed and is altogether easier to work. It is equally important, however, that care be taken in working the corners not to tear the metal, and when dressing it the motion of the dresser should be such as to drive the thickness of the lead toward the corner. When it is all laid smoothly it should be tacked as before and finished by dressing with a piece of sheet lead or flap. Then the sheet should be polished by rubbing with a cloth and sand. Water applied with the sand will help to secure a good finish.

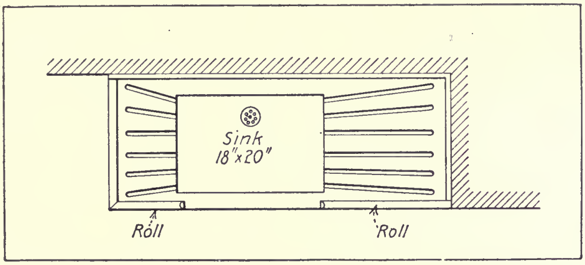


FIG. 159—PLAN OF SINK AND DRIP BOARDS, SHOWING DRIP GROOVES AND ROLLS

As a covering for drip trays of sinks in which chemicals are to be used freely, lead is unexcelled. In fact, it is about the only covering that can be used to advantage and it is also common to line the sinks with this metal. This is a job requiring considerable skill, so much so that in many shops it is hard to find a man who can be entrusted to make a good-looking job when such work comes along.

In covering and lining a sink such as that shown in Fig. 155 two methods may be used. The lining and covering may be done so that part of the sink is lined with the same sheet that is used for the drip tray covering, or the sink may first be lined and then the tray covered separately. The latter is the easiest method and when the lead is put on right is very satisfactory. Seams are necessary in either case and as the top can be put on and the sink lined by the second method so that these are made in parts where they are not subjected to wear or where they will show up very much, possibly the second method is to be preferred.

In following this method the sink is lined first. If it is not very deep it may be found best to beat up the sides so as to have the lining seamless. If the sink is not more than 6 in. deep it will be as easy to do this as to make the lining in the manner in which a sheet-metal box would be made and then burn the seams. If over 6 in. deep time will be saved by the latter method.

When preparing the lining with the intention of beating up the corners the size of the bottom is marked on the sheet and then the desired depth is marked all round this, as shown in Fig. 158. Then with the edge of the dresser the mark indicating the shape of the bottom of the sink is indented a little and the sides bent up to the mark as far as possible. This will leave a flaring dish with the corners resembling exaggerated pig ears. It is the purpose in beating these corners up to proceed until the sides have reached the perpendicular, and this is done with the aid of a wooden dresser.

Holding a rounded piece of wood inside the corner, the workman takes the dresser and commences at the lower corner to dress against the rounded stick. The direction given the stroke is such as to gradually draw the lead up toward the upper edge of the lead sides, and by continued dressing this is finally brought up until at each corner the excess lead is shaped something like a "pig ear."

It is well to try and maintain the corner somewhat round until the sides have been brought up equally all around and until they have been made perpendicular to the bottom. Then they may be squared up by holding a piece of wood inside the angle and dressing against this.

Another help in securing a neat corner in the sink is the dressing up of the angle in the bottom before commencing to work the corners. This may be done with a mallet and it is only necessary to bump the lead upward a little way so as to stiffen the angle when the corner is being beaten up and so maintain a square angle at the bottom which will fit the sink well. When the sides have been brought up sufficiently and the lining has been dropped into place it is time to dress this bump back, and then the sides and bottom will be found to fit snugly back to the woodwork. The sides may finish flush with the top of the tray and a lap can then be provided to prevent washing over.

In preparing the lead to cover the top of the sink the same procedure is followed. The lead is cut of sufficient size to allow for the upstand on the back and one end and to admit of a roll being turned on the front to prevent water or acid from washing over on the floor. The top should also turn down over the front about 1 in. and this must be allowed for. Then the upstand is set up to the mark in the same way as the sides of the sink were set up, that is if the upstand is not to exceed 6 in. If more than 6 in. it will be advisable to make a burned seam at the corner. After this part has been completed the lead is put into place and the position of the sink indicated by dressing down enough to leave a mark all round its edge.

If a lap of 1½ in. is to be allowed this is marked off and the piece cut out. Then the rolls should be nailed on the front and end of the drain board, as indicated in Fig. 159 and the place where the inside corner of these will be is indicated on the lead by pressing down on it there. The lead should then be beaten up so as to form a corner about 2 in. deep at the angle and then the covering should be put down finally.

The next step is to dress it smoothly and proceed to work down the lap in the inside of the sink. In doing so the dresser should be handled so that the thickness of the lead will be driven to the corners as much as posible. As the lead is driven down the tendency is to become thin and it will eventually tear unless great care is taken to reinforce it in this manner. Then the lead must be beaten over the roll and the angle formed by the roll. This is simply a matter of dressing patiently until the lead is over far enough. It should be remembered that the metal is very easily torn and if it is desired to square the lead up where the roll joins the upstand a soft wood wedge will be the best tool to use.

The rolls at the end of the drip boards should be rounded off and the lead dressed neatly down to the level board and then dressed back against the front of the drip tray and tacked with copper tacks. A wooden bead around the upper edge of the upstand makes a neat finish, or the lead may be fastened to the wall with copper tacks spaced at intervals of 1 in., or so. Then the grooves should be run in the drip tray.

These should be run in the wood top about ¾ in. wide at the sink end, and as they must have a pitch, they will run to the end of the board, becoming gradually narrower until they disappear. If the woodwork of the sink is grooved before the lining is put in at a point at which the lap of the covering will occur, the lining may be dressed back, and when the covering is dressed back into the groove also it will be possible to burn the joint and so make a perfectly smooth finish, as indicated in Fig. 156. This will make the burning of this seam easier also.

It is generally advisable to burn this horizontal seam, although it is not always done. If it is neglected, however, there is some liability to have acid soaking through and rotting the woodwork, unless the plan indicated in Fig. 157, which shows a bead designed to prevent this happening, is followed. The inside corners of the sink should be loaded up in the burning process when the seamed lining is adopted, so as to get rid of the very sharp angles and the difficulty of keeping these clean. The connection to the lead trap may be made by bringing the pipe up to the level of the inside of the sink and there burning the edge to the lining. A special strainer will be necessary in any case and this may be made of cast lead and burned into position also.

CHAPTER XVI

ROOF CONNECTIONS, BUBBLING FOUNTAINS, PLUMBING TESTS

The roof connection, as the flashing at the part where a soil or vent pipe passes through the roof of a building is termed, is an important part of the plumbing system inasmuch as it must be made in such a manner as to remain water-tight under all conditions of weather and to provide for the movement of the stack through expansion and contraction also. The most common method of making the connection where the pipe passes through a slate or shingle roof is to take a piece of sheet lead or copper about 20 in. × 20 in. and either beat the lead down around the hub of the pipe as shown in Fig. 160, when cast-iron soil pipe is used or set it up so that the edge will be covered by a coupling as shown in Fig. 161 when wrought-iron pipe is used.

With the same kind of pipe and using copper for the flange, a sleeve is made and soldered to the part that lies on the roof. The sleeve is made large enough to allow the pipe to pass through it easily. Then if the hub is kept a few inches above the roof line the copper may be be turned into it and calked into the joint in the same manner as is done with lead flashings or the hub may be kept about 18 in. above the roof line and the sleeve allowed to come tightly up under the bell. If no hub is used to finish the stack the sleeve may be clamped around the pipe, with roof putty between the copper sleeve and the pipe to make a water-tight connection.

Alternatively, the stack may be finished as shown in Fig. 162. Here lead or copper may be set up to the desired height above the roof and a short piece of pipe with the hub reversed made to finish the stack. The hub is allowed to come down tightly over the upper edge of the sleeve.

Another method is shown in Fig. 163. This allows the stack more movement and is desirable if the stack is a high one, or if very hot water is passed into it in large quantities. The sleeve or the upstand of the lead is allowed to come about 12 in. up the stack and an apron is prepared so that it will cover the upper edge of the sleeve by some two inches. The apron is then beaten into the hub and calked in with the joint. This provides a neat and efficient flashing under the most severe conditions.

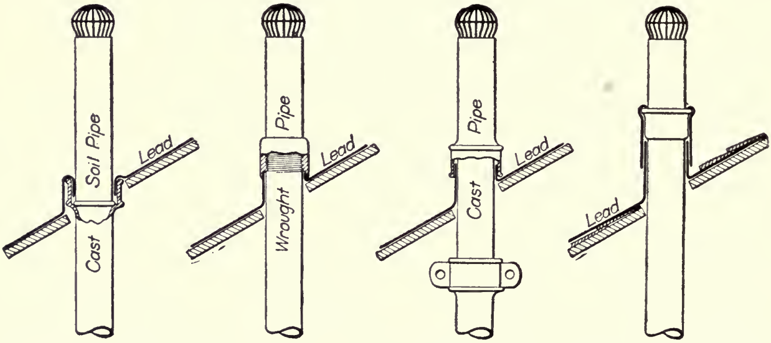


FIG. 160 FIG. 161 FIG. 162 FIG. 163

VARIOUS METHODS OF MAKING ROOF CONNECTIONS

While the increase in size of the pipes passing through roofs is efficient in ordinary climates as a means of keeping them free from ice, it is necessary in sections where extreme cold is experienced to make some further provision. A roof connection which incorporates a sleeve extending to the top of the pipe is shown in Fig. 164. This is intended to protect the outlet from the effect of extreme cold and so prevent its closure with ice.

In addition to these methods there is another which is very efficient and which is shown in Fig. 165. The stack is finished at the roof line by turning a bend through so that the top of the hub will be flush with the roofing boards. Then a lead or copper flashing is put on and dressed down into the hub to a depth of 1 in. Another bend is inserted so that the line of the stack will be again made vertical and the joint is poured and calked securely, thus effecting a water-tight connection with the roof.

Raising Boiler or Pneumatic Tank to Position.

A convenient method of raising a heavy boiler or pneumatic tank to its position on the brackets is shown in Fig. 166. The supports are attached to the floor and wall at the proper position and a plank laid across the supports as indicated. The boiler is rolled up close to the supports and the end of a long plank strong enough to support the weight is inserted while the other end is laid on a saw-horse. A cleat is nailed on this end of the plank and the boiler is then rolled up the plank until it rests against the cleat. One man can hold it there with ease while another raises the end of the plank and places it on the plank already laid on the tank supports. Then the boiler is rolled up the plank until it rests against the wall, another plank is placed across the stays of the tank support and a block laid on this affords a fulcrum for a lever which will raise one end of the tank and allow of the long plank and the short one on the tank brackets being removed with ease. The tank is then allowed to settle down into its final position. Two or at most three men can raise a heavy tank in this fashion without trouble.

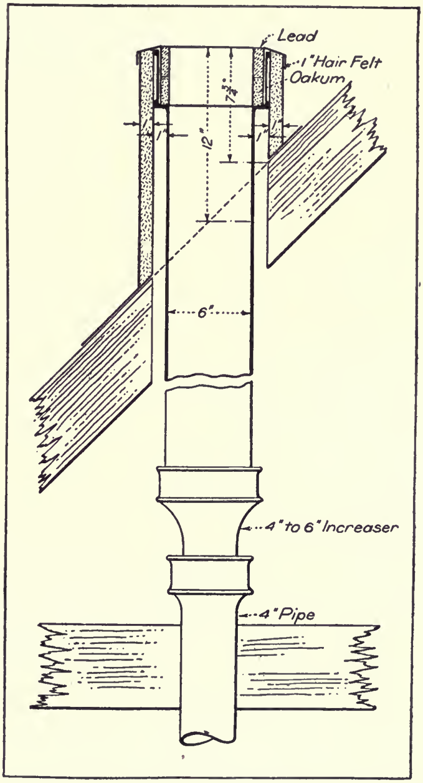


FIG. 164—SECTION THROUGH VENT OUTLET SHOWING INSULATING JACKET

Ice-Cooled Bubbling Fountains.

Drinking water, whether supplied through an ordinary faucet or through a bubbling fountain may be satisfactorily cooled by passing it through a coil of pipe in contact with ice stored in a specially constructed chest or pit. The ice chest shown in Fig. 167 is suitable for a country school or factory building where five or six fountains are to be supplied. It is intended to be placed in the basement and the water is not circulated to the various fixtures, but the pipe is heavily insulated, and consequently when the water has passed through the coil and has been reduced in temperature sufficiently the insulation prevents its warming up again readily. The ice box is lined with tinned-sheet copper and has the space between the outer and inner box filled with some insulating materials, generally sawdust, shavings, mineral wool or asbestos. The water supply is taken from the filter or directly from the street main if filtration is not required and is carried around the walls of the box in a coil of ½-in. block tin or lead pipe, preferably block tin. The size of the box and the length of the coil will depend entirely on the amount of water required by the building. Possibly a box measuring 30 in. long by 12 in. wide and 24 in. deep will be ample. The pipe would be coiled closely around the walls and would pass out from the box at the bottom, where a faucet should be placed so that the coil could be emptied when required. The pipe leading to the coil and from it to the fixtures may be of iron or brass if desired and can be connected to the tin pipe by means of unions.

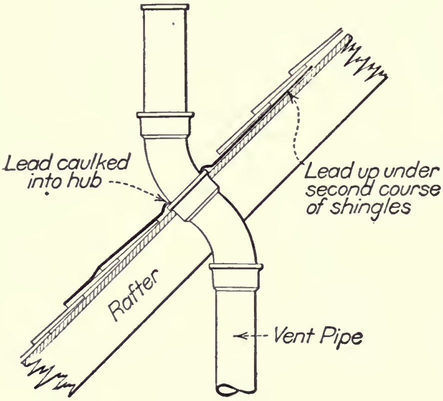


FIG. 165—EASY METHOD OF FLASHING STACK WITH LEAD

The drip from the ice is relieved through a trapped waste pipe which should deliver over a plumbing fixture in the basement. If it is desired to keep the cooled water in circulation the ice chest should be placed in the attic and the supply to the faucets taken from the bottom of the coil so that the water will fall directly to the cellar. As the temperature rises through exposure to the warmer air in the building the density of the water becomes less and it will rise to the tank from which the coil is supplied. This system is said to be unreliable owing to the slight difference in the two columns and consequent slow circulation. It might be improved by the use of a small rotary pump.

Another method of cooling water by means of ice is shown in Fig. 168. This is suitable for outside drinking fountains in playgrounds or athletic fields, or parks. It is in use in a southern city.

These fountains are usually located in a semi-circular space on the inside line of the sidewalk, the circle being about 6 ft. in diameter and the center of the fountain being about 3 ft. from the sidewalk line, so that it may be used without interfering with general travel on the street. The fountains are of the bubbling mouthpiece type and supplied with water through a $\frac{3}{4}$-in. pipe and provided with a 3-in. drain for the waste. The newer fountains are to be provided with cooling coils, and while no authority to buy ice exists, it is the hope that some method for defraying the expense of cooling the water in the summer season will be forthcoming.

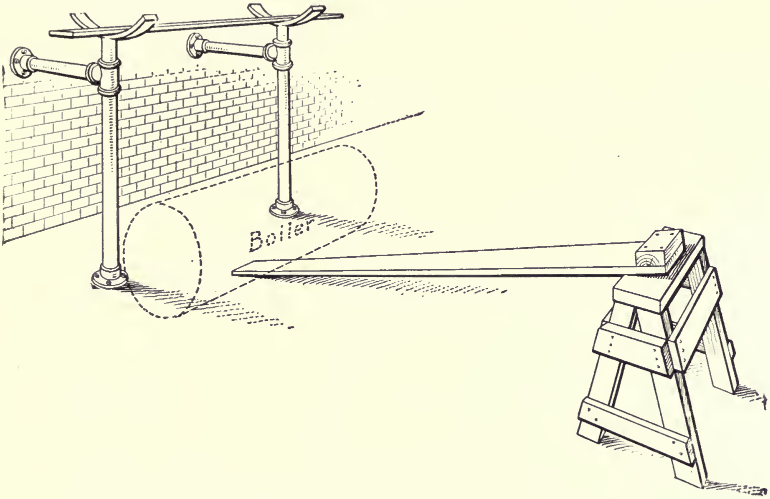


FIG. 166—METHOD OF RAISING BOILER TO SUPPORTS

Beneath the sidewalk a chamber 3 ft. 3 in. × 2 ft. $1\frac{1}{2}$ in., inside dimensions, is provided, having a general depth of 2 ft., with a further depression or pit for the cooling coils about 9 in. deep. These coils are to be made of $\frac{3}{8}$-in. block tin arranged in a coil of four layers occupying a space 20 × 28 in. in size. The construction of the cooling pit provides for a rack above this piping on which the ice is to be laid. These coils are not permanently connected, but by means of rubber hose they receive a water supply through a

¾-in. pipe, and this in turn is connected with a ¼-in. pipe leading to the bubbling mouthpiece at the top of the fountain proper. The use of ruber hose in connecting the piping permits the removal of the cooling coils at the season of the year when they are not in use to prevent their becoming frozen. Across the bottom of the pit provision is made for arranging a series of grate bars on which the ice will rest, a recess in the side wall being provided for the ends of the bars, which are 1½ in. in depth and ⅜ in. in width. Two heavier grate bars are used in the center and at each end, and at one end the grate bars are arranged to allow the piping to pass as shown. At the top the bars are also provided for supporting the concrete top, in which a cast-iron frame and cover are arranged with a further cork cover underneath to serve as an insulator. The bubbling type of mouthpiece avoids the use of unsanitary drinking cups, and is placed at the top of an ornamental pedestal standing in the center of the space inclosed for the larger part with a concrete wall something over 6 in. high. The appearance is agreeable, and the fountain presents practically nothing to get out of order or to be damaged by the careless or vicious, and is admirably adapted for a useful public service.

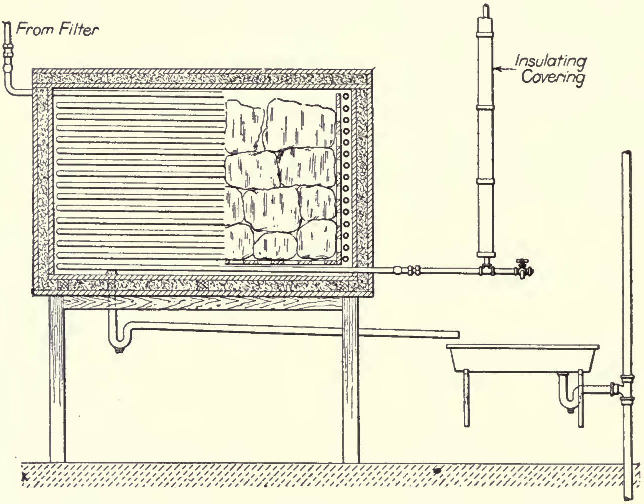


FIG. 167—ICE CHEST FOR SUPPLY OF COOLED WATER UNDER PRESSURE

Testing Plumbing in the Rough and at Completion.

In order to prove the effectiveness of a plumbing system in regard to the prevention of the entrance of sewer air to the building it is customary to require two tests to be made. The first of these is applied to the soil and waste piping while the job is in the rough; that is, before the partitions in which the pipes are set have been plastered over, or before any pipes have been covered in so as to be inaccessible. Such a test is usually made with water

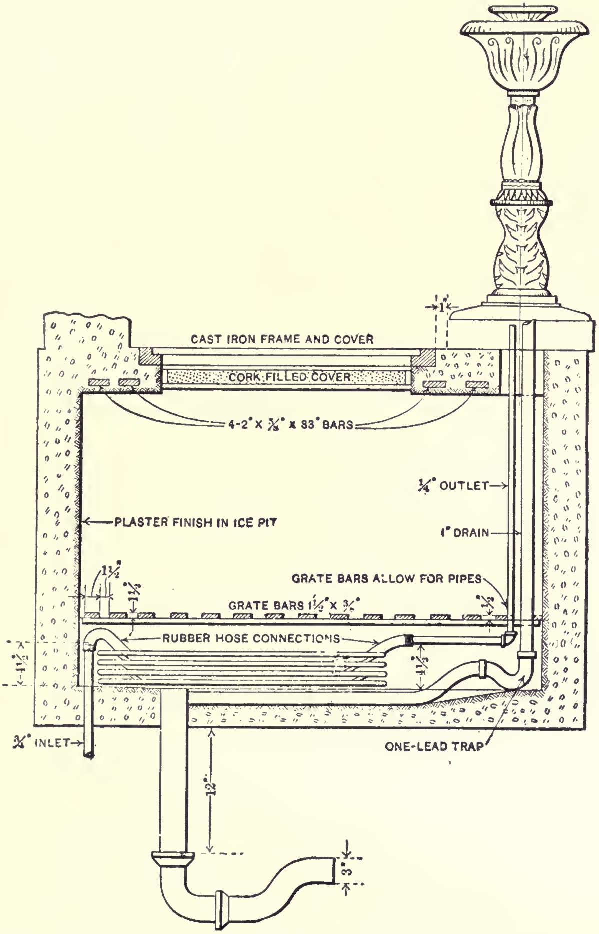


FIG. 168—PUBLIC DRINKING FOUNTAIN WITH COOLING COILS

and simply consists of filling the system from house trap to roof vents with water and examining every joint and connection on the job to see if there is any leakage.

To enable the lower ends to be stopped so as to hold water special plugs are used. These are constructed with an expansible ring of rubber which on the plug being inserted in the end of a pipe or the hub of a fitting may be caused to draw tightly against the walls and so prevent water from passing through. A screw with a lock nut on which wings are provided enables this to be done with ease.

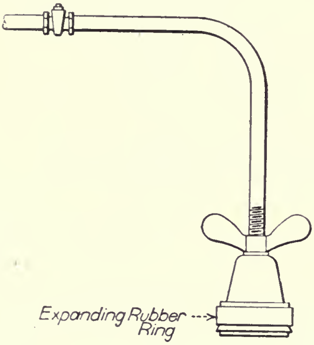


FIG. 169—A DRAIN TEST PLUG

Various minor differences in test plugs are met with, but the type shown in Fig. 169 is representative of most. The pipe passing through the end of the plug and upon which the thread that enables the ring to be expanded is made is used as a connection through which water may be pumped or delivered by gravity. A stopcock allows this to be done and affords a convenient means of drawing off the water as well as of filling the system. When leaks in calked lead joints are discovered they are more or less easily made tight by further calking, but sand holes or cracks in the iron pipes are harder to stop satisfactorily. It should be insisted upon that cracked fittings or pipes be removed and replaced. Sand holes may be tapped and plugged with small gas plugs or they may be filled with "Smoothon" if small. All cleanouts should be fitted with proper washers before testing is begun as otherwise they will leak at the threads. The test may include all of the iron pipe, even beyond the main house trap, and when this is so, a tee or other opening should be left at which it will be possible to insert a plug. The water should be made to stand up to the level of the vent outlets at the roof and a note should be made as to the length of time it takes to recede. This will be some guide as to the extent of any leaks which may require attention. When the job is perfectly tight the water will stay level with the top of the vent pipe.

Lead bends and traps must be soldered up temporarily. If the type of lead bends which have one end spun closed for testing purposes are not used the closet bends may be closed with ease if a piece of roofing tin is soldered into them lightly. It should be soldered as close to the upper end of the bend as possible so that stock will not be wasted unnecessarily should there be little to spare to make the floor connection.

Vent connections should be closed temporarily with plugs, or lead ends on small-sized pipes squeezed together and soldered tight. Particular attention should be given to the inspection of brass ferrules owing to the liability to sand holes found in cast-brass connections.

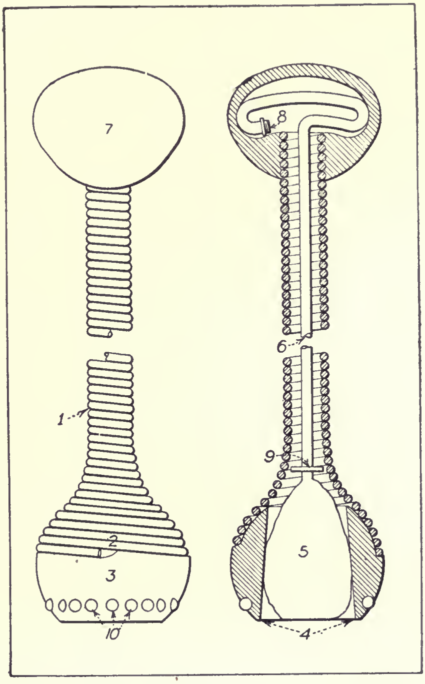


FIG. 170—IMPROVED PLUG FOR TESTING CLOSET JOINTS

The final test may be applied by smoke or by peppermint. The former is by far the more reliable as unless the greatest care is exercised one or the other of the men making the test will bring into the building the odor of peppermint and make it impossible to locate a leak. It is applied by first stopping the lower end of the pipe and then by pouring a little oil of peppermint into the vent outlet on the roof. Immediately the oil has been put into the pipe some hot water is poured after it. This causes the oil to volatilize and as the upper end is immediately closed the pungent odor will find its way through any leak in the system and be noticed by those in charge of the test and who have been inside while the oil is being applied.

The smoke test possesses an advantage inasmuch as any leakage of smoke is noticeable to the eye as well as to the olfactory organ. It also is applied from the roof as a rule, although it can as well be applied through the fresh-air inlet or through some trap which has been emptied for the purpose. The smoke is produced in a special machine consisting of a fire chamber and a small bellows. The fire chamber is a miniature gasometer as the smoke-producing medium is contained in a drum set in the center of a water tank and a bell floats over the container and is water-sealed thereby. The smoke leaves the container through a pipe turned up inside so that its end is nearly at the top of the bell.

The bellows is intended to blow air into the container, thereby providing oxygen to maintain combustion and also the necessary force to send the smoke into the drains. Should the system prove to be tight or nearly so the floating bell will remain elevated for some time if the air connection from the bellows is closed. A valve is provided for this purpose. The seal of the bell is about the same as that of the traps on the plumbing fixtures and these will not be forced if the machine is operated properly.

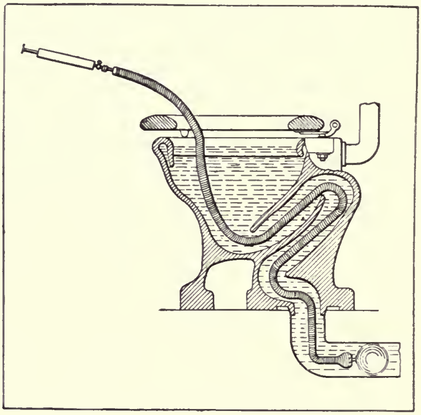


FIG. 171—TEST PLUG IN POSITION

After the system is filled with fresh smoke it is only necessary to keep the bellows moving very slightly, and as soon as the smoke appears in sufficient volume at the roof vent pipes these are closed and the system inspected for leaks. These are easily apparent as the smoke is dense and pungent. Tar paper or cotton waste soaked in oil make a dense smoke suitable for the purpose.

If it is necessary to test part of a drain which has been covered a rubber bag may be inserted through a tee and inflated. As the pressure applied is small this makes a perfectly satisfactory plug for the purpose. This is also a convenient method of stopping branch lines if the system to be tested is a large one and it is desired to test it by sections.

The test plug shown in Fig. 170 is intended to be used in making a test of the floor connections of water closets. It consists of a rubber bag encased in a shield of heavy rubber and provided with an air pipe through which the rubber bag may be inflated. The air pipe is protected by a flexible steel tube which serves the double purpose of protecting the air tube and affording a means of passing the plug through the seal of the closet trap to the desired point in the soil pipe. The tube may be made any length and the bag is inflated by an ordinary bicycle tire pump. Fig. 171 shows the plug in position for the test which consists of filling the closet to the top with water. A leak at the floor connection may then be seen.

CHAPTER XVII

STRUCTURAL FEATURES OF COUNTRY-PLUMBING SYSTEMS.

As a rule the plumbing equipment in farm buildings is of the simplest description, but the demand for better sanitary conditions has led to the development of special fixtures which enable the workmen to keep buildings such as stables and cow barns in satisfactory condition with little trouble.

It is essential that there be a liberal supply of water and proper means of draining the buildings so that the hose may be used freely. If a stable is provided with a concrete or brick floor drained to one or more floor drains the attendants can without trouble keep it in a wholesome condition. It is customary to pitch the floor outward from the stalls to a shallow gutter drained through a special floor trap such as is shown in Fig. 172. Straw, mud and other matter which may be washed into the trap is collected in the receptacle which is hung in the large cast-iron chamber and may be removed from time to time with ease. The trap also has a deep-water seal, which is desirable on this class of work and where there is any chance of siphonage occurring the seal may be ventilated through the hub provided on the outlet. A handhole at the outlet also provides access for cleaning at the point.

The same floor trap may be used with satisfaction in cow barns and should be used in the same manner; namely, in gutters running along outside the stalls. The gutters should be shallow and wide, with rounded bottoms. In some barns the gutter is barely discernible as the grading of the floor is such that the lowest point is at the place where a gutter would be formed and water is conducted to that point and so to the floor traps.

In cow barns it is not generally desired that a permanent supply of water should be provided the animals. A long trough, made of reinforced concrete or slate, or iron if preferred, is constructed at the head end of the stalls, running the entire length of the range. At one end of the trough a faucet is provided and at the other an outlet with a plug and socket. Water is turned into the troughs at regular intervals and allowed to remain until the animals have had sufficient. Then the trough is emptied and used for feeding. It is necessary that it should drain thoroughly, and it is also desirable that the outlet should be constructed so that the pipes conveying the water will be accessible for the removal of straw and other matter carried out from the trough. It is a good plan to make the outlet deliver over a floor trap as shown in Fig. 173. Then the refuse will be collected in the receptacle and removed periodically as is done in the rest of the traps in the building.

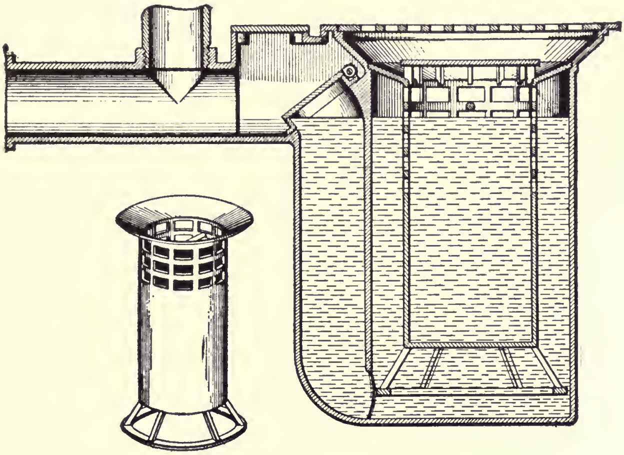


FIG. 172—STABLE OR COW BARN FLOOR DRAIN TRAP

Horses are often provided with drinking troughs in which a supply of water is automatically maintained. This may be done as is shown in Fig. 174. Here the troughs are placed beside the regular mangers and consist of iron or vitreous ware sinks some 10 in. deep filled from a water-supply pipe connecting with a storage tank at the end of the row. The tank is set on a level with the troughs and the water-line is maintained by a ballcock at the height to which it is desired the troughs should fill. A pipe 1 in. in diameter will provide a sufficient supply and plugs should be provided at each end so that in the event of stoppage it will be easy to pump the stoppage, generally oats and other feed out of the pipes.

The equipment of a small dairy as a rule consists of a trough or tank in which milk pans and other receptacles may be washed thoroughly, another in which they may be sterilized in boiling water, a sink at which the workers may wash up and any other plumbing fixtures of the ordinary type which it may be desired to install.

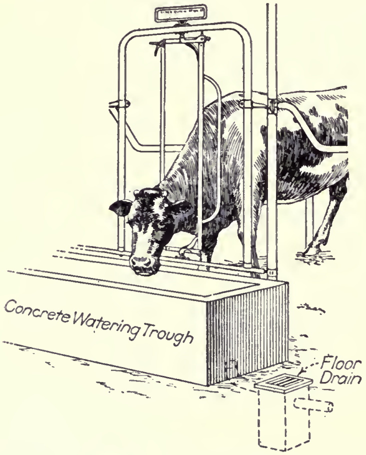


FIG. 173—METHOD OF DRAINING COW TROUGHS

The troughs are fitted with traps on the waste pipes, connected with the drains and vent pipes exactly as a wash tray or kitchen sink would be, but the troughs themselves are, as a rule, of heavy galvanized iron and may be described as tanks rather than troughs, as generally understood. The washing trough is provided with an ample supply of hot and cold water. The faucets should have hose connections and if bottles are used it may be well to provide spray jets for rinsing purposes. These are attached to the iron work of the trough and are connected with the water supply through self-closing valves.

The sterilizing tank, besides being provided with hot and cold-water connections has a steam supply and a perforated pipe in the bottom through which it enters. By this means the water is brought to the boiling point and the cans and other articles contained in it thoroughly sterilized. The steam may be provided from a power boiler, or a small generator specially designed for the purpose may be utilized.

The floors of a modern dairy are of concrete also and are provided with floor traps and gutters so that the whole interior may be washed frequently. Hose cocks should be located at various points so that every point will be within easy reach. A water supply will also be required for the cooler if such is used, but the makers of such appliances indicate how they should be connected.

All drains under floors of stables, cow barns and dairies should be made of cast iron, and cleanouts should be placed at every change of direction. The amount of foreign matter washed into the drains makes this provision imperative.

Plumbing in a Small Garage.

Practically the only equipment required in a small garage, unless it is also designed to provide quarters for the chauffeur is a water supply, a floor drain and a wash-up sink.

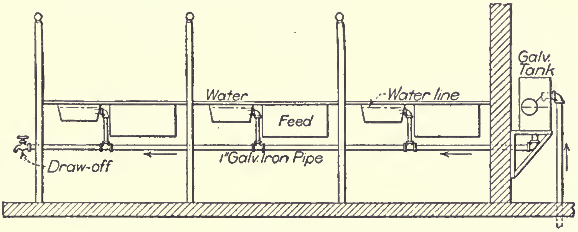


FIG. 174—HORSE DRINKING TROUGHS AUTOMATICALLY SUPPLIED

The water supply is a necessity and if a warm-water supply is also available it will be found of the utmost convenience. If gas is available an automatic heater is the best appliance to use. It should, of course, be located in an apartment away from where the fumes of gasoline will reach it. The same type of heater may be used with gasoline as a fuel in sections where illuminating gas cannot be used.

If permanent quarters for the chauffeur are provided a bathroom is a necessity, and in that event it may be desirable to provide a small storage tank and heater either of the gas or coal type. The equipment of the bathroom will be made as in any other residence and in the garage proper there should be a sink at which water may be drawn or small articles washed.

A hose bibb or a carriage washer should be located at a convenient point. If a special section of the floor is set apart for washing the car the hose bibb or overhead washing arrangement should be located accordingly. The water should be drained from the floor to a special garage trap of the type shown in Fig. 175. This is designed to prevent sand, mud or small particles of straw and other matter from being washed into and eventually stopping the drain. The receptacle seen in the illustration retains it and by periodical cleaning the trap will keep the drain free from stoppage. Oil and gasoline are also prevented from reaching the sewer, as being lighter than water they float on the top of the seal. Vent pipes connected to the hubs on the receiving hood maintain a circulation of air through the trap, and in consequence the gasoline brought in with the wash water is evaporated before it can form in dangerous quantity in the trap.

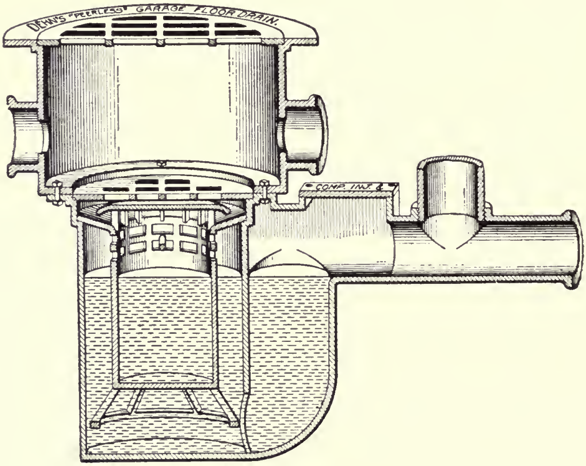


FIG. 175—SPECIAL TYPE OF GARAGE FLOOR TRAP

A floor trap may also be used with advantage in the bottom of the inspection pit. If such is used one with a deep seal should be chosen as it is likely to be overlooked and if little water finds its way into the pit for a few weeks may become unsealed through evaporation.

A type of garage trap which has been recommended for use in many cities is illustrated in Fig. 176. This may be built of brick or concrete and is intended to receive all of the washings from the floor of the garage. It is large enough to ensure that the water will pass through it slowly so that the oil and gasoline carried into it with the floor washings may have time to rise to the surface of the seal and an improvement on the design is made when a vent pipe is provided. This is inserted at a point near the top and is carried to a high point outside the building. The circulation of air over the seal assists in evaporating the gasoline and carrying the fumes away. The minimum depth of seal recommended is 12 in. and the depth of sludge which may accumulate before the outlet is closed 12 in. Therefore, the pipe leading into and out of the trap must be set at a distance of 24 in. from the bottom. This is indicated at *A* in the illustration and the water seal at *B*.

Storage of Gasoline.

The most approved method of storing gasoline in quantities is that where an underground tank is used. The tank may be placed in any convenient location and the gasoline may be raised by air pressure or by a pump. The air-pressure method is simple and effective. It requires only a connection to an air pump placed in the garage and a gasoline pipe leading from the tank to a faucet placed close to the air pump as shown in Fig. 177. If a suction pump is used the connections are the same, but the pump is placed

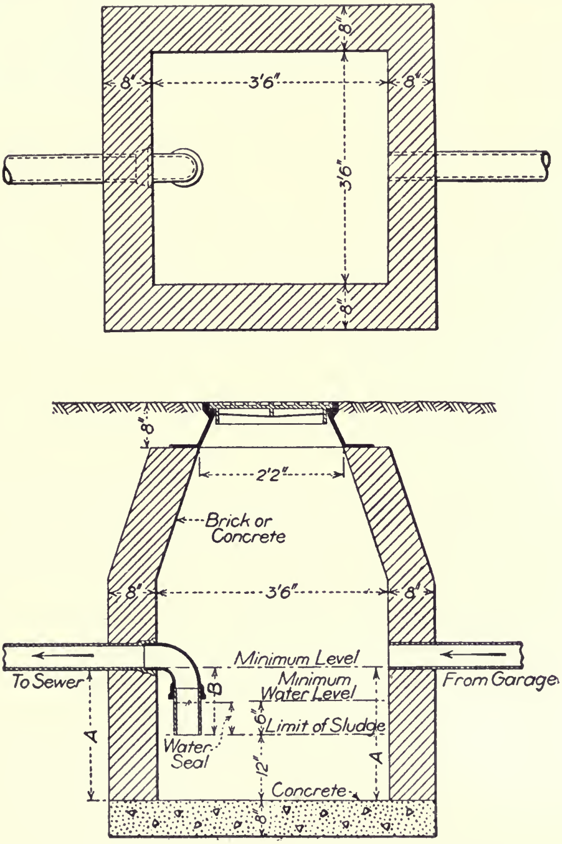


FIG. 176—CONCRETE TRAP FOR USE IN GARAGES

where the faucet is shown. An extension from the tank to the surface is made so that the tank may be filled with ease. This pipe should project above the ground level and should be fitted with an air-tight cap when air pressure is used to raise the gasoline. When it is to be pumped up there should be a small air valve in the cap.

Features of Factory Plumbing.

A good type of sink to use in a factory washroom where particularly grimy hands are to be washed is shown in Fig. 178. The advantage that is possessed by a sink such as this over individual basins is that grit, the rouge and other polishing materials used in brass and other factories, sand and such matter is caught and retained in the sink instead of being washed into the waste pipes.

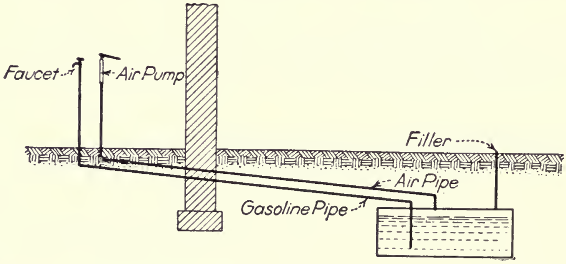


FIG. 177—METHOD OF INSTALLING GASOLINE STORAGE TANK

Individual wash basins are provided the workmen when a long sink is used and the supply fixtures are spaced so that each man has ample room to use it. If the supplies are run along the center of the sink as indicated, both sides of the sink can be used to advantage, and, therefore, a shorter sink will provide ample facilities if it is possible to set it in the center of the room.

The hot and cold-water lines are carried overhead and connections are made at two points. One of the drop pipes is the hot supply, the other the cold and the horizontal lines to which the faucets are connected are supported by pipes carried to the floor at each end of the sink. A solid nipple inserted at the end of the line stops the supply at the last tee. The two pipes are held together by brass clips and bolts. Self-closing cocks are used on the drop pipes and the hot and cold stops are placed together so that a basin may be filled with water at the desired temperature at one operation.

A type of factory washroom lavatory which is used extensively has individual basins of cast iron supported by the water-supply lines. These are of 2-in. pipe and run along the center of two lines of basins or along the back if only a single line is desired. Brackets are bolted to the water-supply lines and these come down and provide a firm support for the basin. The waste lines are of brass and a trap is fitted to each basin. As a rule a cleanout is placed in the end of the waste pipe which is carried to the end of the range and connected with the waste and vent line there.

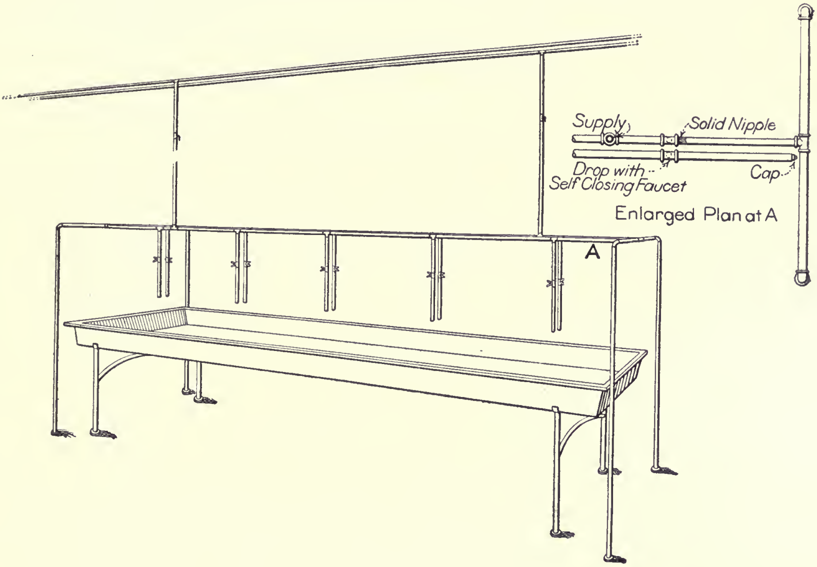


FIG. 178—FACTORY WASH-ROOM SINK

Cleanouts should be used freely in factory plumbing on account of the large amount of grit present in the waste water and the risk of foreign matter finding its way into and choking the pipes.

Factory Toilet Rooms.

If the toilet rooms in a factory are situated on the ground floor only, the arrangement is comparatively simple and as a rule a group of closets may be connected so that the system of venting known as loop venting may be employed with satisfaction. This calls for the continuation of the main soil pipe to the end of the range and so to the roof of the toilet room. Where fixtures enter the stack on floors above the toilet room, however, it is necessary to re-vent each closet bend so that there will be no danger of siphonage, although a modified system of loop venting is also possible in this case.

For instance, the connections illustrated in Fig. 179 are intended for a toilet room situated on the ground floor. The soil pipe to which each closet branch is connected is carried out in the regular manner, the end farthest from the vertical stack is simply carried through the roof to act as a vent pipe. In Fig. 180 another condition is shown. Here several toilet rooms are situated immediately above each other. While loop venting might be used throughout it is safer to use the system illustrated; namely, a regular re-venting system for all of the floors except the top one. Then there is absolutely no danger of siphonage or pressure breaking the seals of any of the closet traps. As the upper toilet-room fixtures are not subjected to the action of heavy bodies of water passing the connection to the vertical stack it is perfectly safe to use only the loop vent on that floor. The illustrations show the manner of connecting the closets with lead pipe, although iron or brass pipe may be used with equal satisfaction if a floor flange connection is used with the closets.

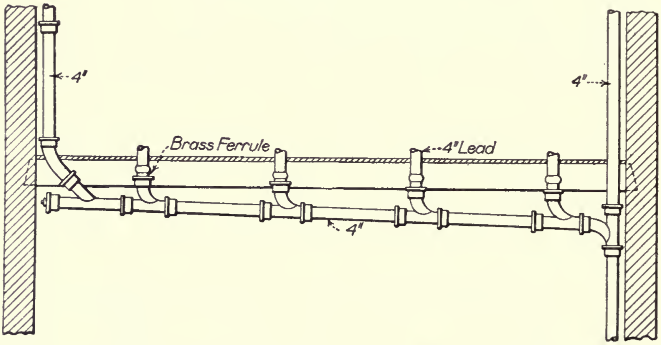


FIG. 179—CONNECTIONS FOR TOILET ROOM ON GROUND FLOOR

Heavy brass ferrules are used to connect the lead to the iron, and brass pipe of iron-pipe size makes the connection between the 2-in. lead and the 2-in. iron-vent pipes.

In nearly all factories bubbling fountains are now provided instead of the old common drinking cup. Many patterns of fountains are available for factory use. Some of these are provided with cooling chambers which may be placed below the floor or ground and which are constructed so that the supply pipe passes to the fountain around a coil of pipe in a chamber containing ice. Others are designed to be placed where faucets of the common pattern have been replaced, and in such cases it is only necessary to remove the faucet and put the drinking fountain supply pipe in its place.

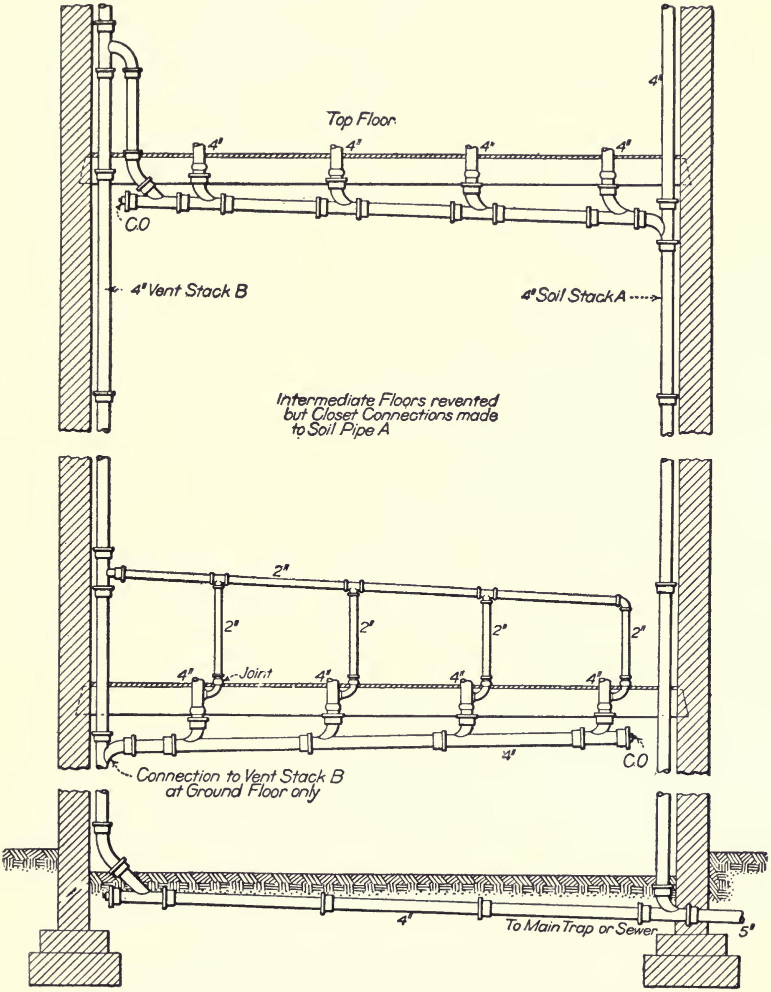

4"
Top Floor
4"
4"
4"
4"
C.O
4" Vent Stack B
4" Soil Stack A
Intermediate Floors revented but Closet Connections made to Soil Pipe A
2"
2"
2"
2"
2"
4"
Joint
4"
4"
4"
4"
C.O
Connection to Vent Stack B at Ground Floor only
4"
To Main Trap or Sewer
5"

FIG. 180—CONNECTIONS FOR TOILET ROOMS ON TWO OR MORE FLOORS

These fittings project some 9 in. from the back of the sink so as to distribute the waste water about the center of the sink and so obviate splashing. A fountain of this type is illustrated in Fig. 181.

Waste Pipes from Acid Tanks and Laboratory Sinks.

When it is necessary to convey wastes from sinks or tanks in which corrosive acids are used in a more or less dilute state tile pipe is generally chosen. Lead pipe will resist successfully the action of muriatic or sulphuric acid for a considerable time, but will succumb to nitric acid very quickly. Iron pipe will be attacked by all of these and also by acids of a less corrosive nature in a short time as will copper and brass. The vitreous enamelled tile resists the action of these acids best of all, and, therefore, while lead-lined iron pipe or heavy-drawn lead pipe are used to a considerable extent the tile pipe is preferable.

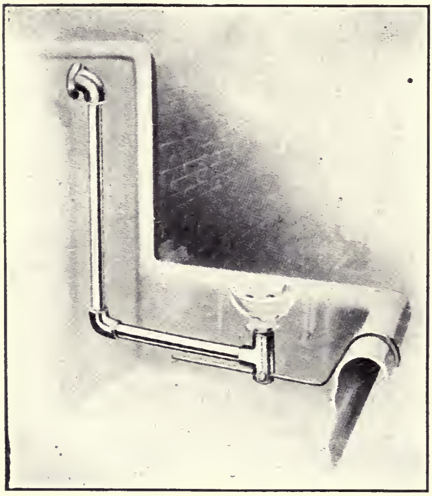


FIG. 181—BUBBLING FOUNTAIN ATTACHED TO SINK FAUCET

A special pattern of the pipe with flange joints is made for this purpose, but if first-class drainage tile is used and the lengths are carefully selected there is no reason why it cannot be made to give equal service. The principal requirement is that the joints shall be carefully made and that the pipe shall be well supported. In Fig. 182 is shown a waste pipe from a factory sink carried out in 4-in. tile. The support necessary to prevent the cracking of joints by sagging is given through the use of a board supported on brackets and upon which the pipe lies.

The joints are made by means of oakum soaked in hot asphalt and calked as if a regular lead joint were to be made. The joint is faced up with Portland cement to secure a neat finish and the connection to the sink, which is lead lined, is made by means of extra-heavy lead pipe with burned joints. The asphalt should be kept warm while the work is in progress and the oakum should only be dipped in when it is about to be placed in the joint, as it soon becomes too hard to calk easily.

Plumbing in Small Town Flat Buildings.

Practically the same conditions prevail in flat buildings in small town as in cities as regards the plumbing requirements, excepting that the lower height of the buildings as a rule simplifies the piping system and admits of simplification of the vent pipes. It is permissible in some cities and generally in villages to install waste and soil pipes without re-vents, but when this is done the arrangement of the piping should be such as to remove the danger of siphonage as far as possible.

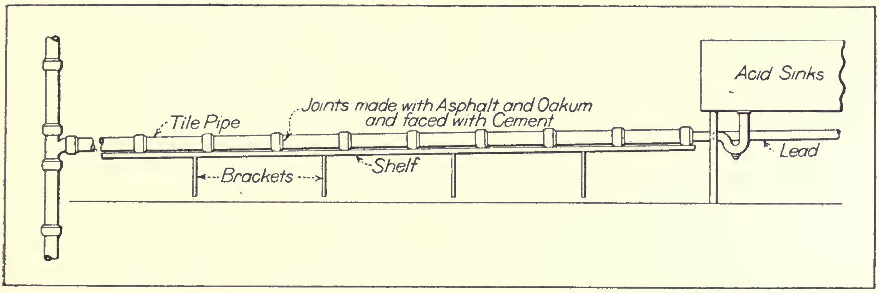


FIG. 182—METHOD OF CONNECTING WASTE PIPES FROM CHEMICAL SINKS

This may be done by connecting the soil and waste pipes from a bathroom, for instance, into the 4-in. vertical line instead of bringing both soil and waste lines together into one tee. The use of deep seal or drum traps is also resorted to for the same reason, as they retain a larger volume of water than the ordinary round-pipe trap, and consequently are more likely to resist the action of siphonage or pressure in the vertical pipe.

Sink and laundry-tub wastes should be carried in separate lines and unless non-siphoning traps are used a vent line should at least be provided for the traps of the laundry tubs, which are used less frequently than the sinks. A simple system is shown in Fig. 183. This protects the seals of both sink and tub traps, although it is not generally considered advisable to have a waste line also act as a vent pipe owing to the liability to become choked.

If the building is over three stories in height, vent pipes should be used in any case as the discharge of several fixtures at one time on the upper floors may cause sufficient pressure to blow the seals of the traps on the lower floors. The arrangement of bathroom connections and vent lines shown in Fig. 184 is as simple as can be devised and will prevent this happening as well as prevent siphonage of the traps after the body of water has passed the branch on the vertical stack, while the additional expense incurred through the venting is not prohibitive.

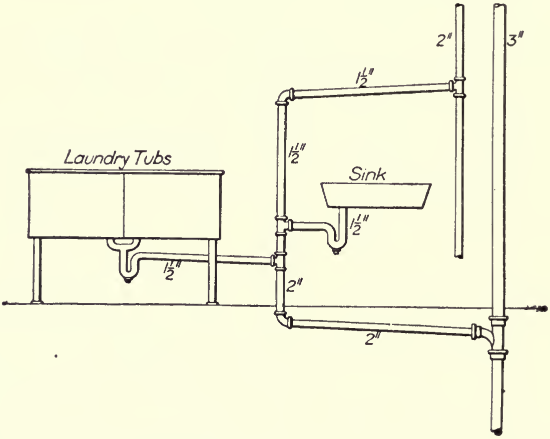


FIG. 183—SIMPLE VENT AND WASTE CONNECTIONS TO SINK AND LAUNDRY TRAPS

Refrigerator Waste Lines in Flat Buildings.

Where a line of waste pipe is installed to take the drip from a number of refrigerators, a waste pan should be made to stand under each refrigerator. This may be made of wood, about 12 in. × 12 in., pitching sharply to the center as shown in Fig. 185. The depth of the pan at the outside may be 3 in. or more as desired, and it should be lined with lead or copper. The waste pipe from each pan should be not less than 1¼ in. in diameter and may be of lead. The connection to the pans should be made so as to allow of a strainer being placed inside the pipe and a screw cleanout should be soldered into the outlet at its connection with the pan. This is to provide a ready means of stopping the entrance of cellar air at such times as the refrigerators are not in use. The vertical line should be of 1½-in. galvanized iron and the branch tees should be of the sanitary pattern. A trap should be placed at the foot of the stack and the end of the pipe should be made to deliver over a sink placed in the cellar. The upper end of the vertical line should be carried out through the roof and finished in the same manner as the vent pipes from the rest of the plumbing system. If the branch lines from the refrigerator pans are long, cleanouts should be provided and boards cut in the floor to provide easy access at any time. The trap at the foot of the line should be placed on

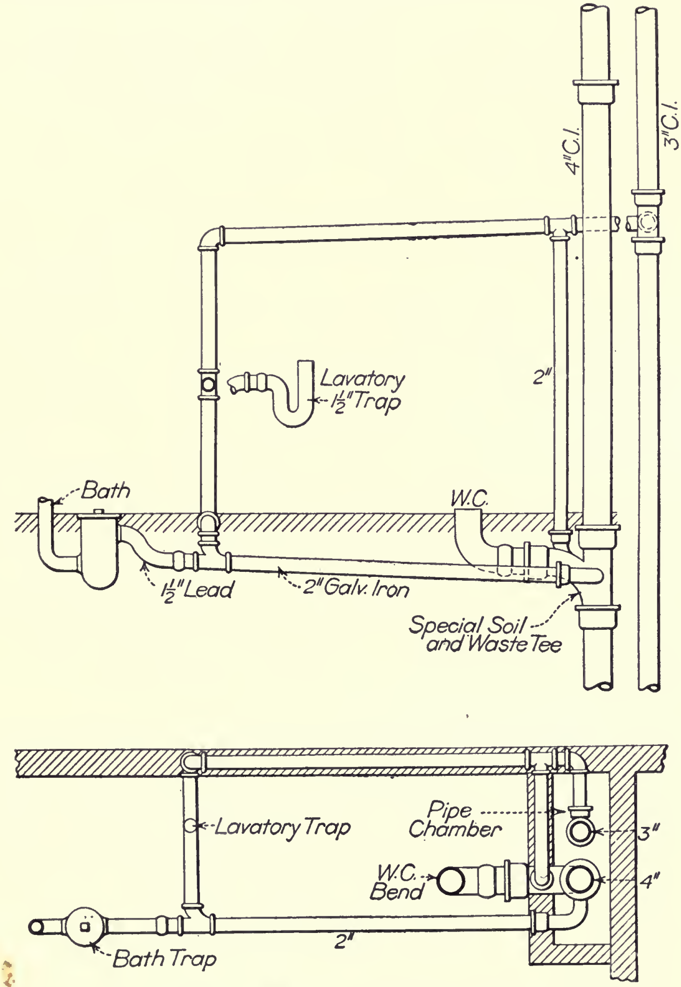


FIG. 184—BATHROOM FIXTURE VENT AND WASTE LINES

the horizontal pipe running to the cellar sink and should have cleanouts as shown.

Supply of Water to Basement Laundries.

In some sections the laundry equipment for each tenant is placed in the basement, while the supply of hot water required is provided from the regular kitchen boiler in the flats on the various floors. When this construction is adopted the hot-water pipes are installed as shown in Fig. 186. A branch line is brought down to the basement from each hot-water boiler and is connected into the pipes supplying the laundry tubs through a valve which is under the control of the tenant. By this means each is caused to provide fuel for heating the water required and each draws only as much hot water as is provided by the range in the kitchen above. The branch lines are provided with pet cocks or plugs so that they may be emptied when the flats are unoccupied.

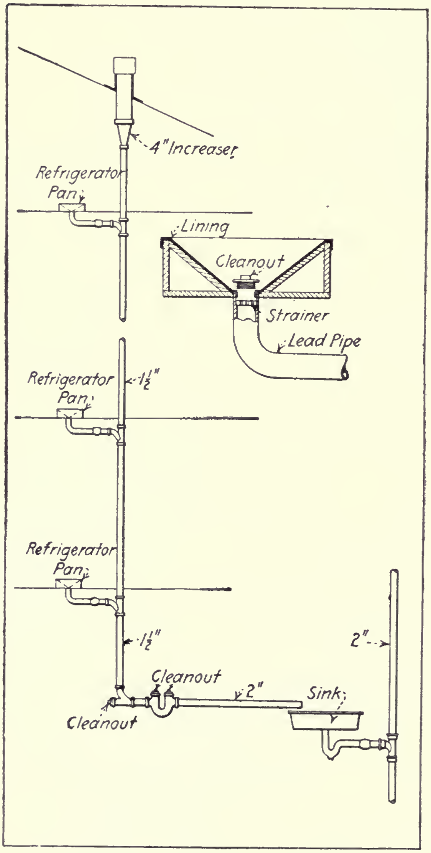


FIG. 185—METHOD OF INSTALLING REFRIGERATOR WASTE LINES

It is sometimes a hard problem to supply fixtures in outbuildings such as garages or dairies with hot water from the same plant as is used to supply the house fixtures and if the distance is great it is seldom economical.

If a long pipe is carried to such fixtures without provision for circulation a considerable quantity of cold water will have to be drawn before hot water is available and it is therefore desirable that a circulating system be used where possible. If the heater and storage tank are in the basement of the main building this is not a difficult problem as a rule but if the kitchen range and boiler is used for the general hot water supply it will be necessary to carry the supply pipe for the outbuilding to a point 15 to 20 ft. above the boiler before turning down to the ditch in which it is to be run.

The reason for this is that it is necessary to create sufficient motive force in the flow and return pipe to the outbuilding to secure constant circulation and the cooling surface exposed in the loop above the boiler is sufficient to assure this. The water in falling through the downward part of the loop is becoming cooler and in consequence more dense than the water entering the loop from the boiler therefore circulation is promoted. If it is necessary to rise to a higher point than that at which the horizontal pipe starts out in the ditch, the high point should be in the outbuilding and should be vented there. If the pipe can be kept pitching downward all the time until it returns to the main building a vent will be unnecessary. The pipe should be well insulated.

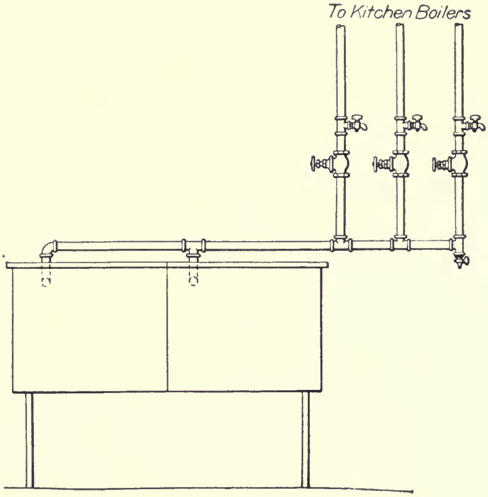


FIG. 186—METHOD OF CONNECTING HOT WATER SUPPLY PIPES TO BASEMENT LAUNDRY.

CHAPTER XVIII

EXAMPLES OF WORK IN COUNTRY SCHOOLS, OFFICE BUILDINGS, STATIONS, AND OTHER PUBLIC BUILDINGS.

The toilet rooms of office buildings, schools and other places where hard usage may be expected should be designed so as to afford every facility for access and repair of the parts connected with the plumbing fixtures. On this account it is often desirable to adopt the style of construction shown in Figs. 187 and 188, where a pipe chamber is formed behind the fixtures and wall outlet closets are used. This may not be necessary where the pipes can be run on a basement ceiling or in some other location where they will be equally easy of access, but if the toilets happen to be located in the basement or if the ground beneath the building is excavated the pipe chambers are a decided advantage.

In Fig. 187 is illustrated a typical layout for a toilet room for a small school. The layout is equally applicable to a general toilet room in a hotel or office building. All that would differ would be the grouping of the fixtures which, as shown, are located in two rooms, one for boys and the other for girls.

The floor drain traps should be of the type which receive and retain all foreign matter so that matches, straw and other litter will not find its way into the house drain. The floor drain is ventilated as well as the soil pipe by a combination of loop and continuous venting. The lavatory wastes enter this line for the purpose of keeping it more free from corrosion than it otherwise would be but these can connect to the soil pipe when preferred. The arrangement of the continuous vent pipes is shown in Fig. 188 and the method of erecting the marble or slate partitions between the stalls in Fig. 189. The soil and vent connections to the closets are shown in Fig. 190.

Where the connections to a battery of closets are to be made

Where the connections to a battery of closets are to be made under the floor the connections to the vent pipes may be made in any of the ways shown in Fig. 191. This illustration shows the loop system of venting and is satisfactory when the number of closets is small. Several methods of making the loop connection are illustrated, showing how cleanouts may be located advantageously. If there are a large number of closets in the battery the bends should be vented back in the regular manner to the main stack.

In Fig. 192 are shown the connections for a urinal with the flushing valve operated by a push button over it. Flush tanks may be used if preferred but the valve is neater and easier to install. Flush valves on the closets are also to be recommended in such an installation as they may be placed in the pipe chamber and may be operated either with a lever or with a push button.

Two types of flush valves are illustrated in Figs. 193 and 194. The type shown in Fig. 193 with a lever handle operates as fol-

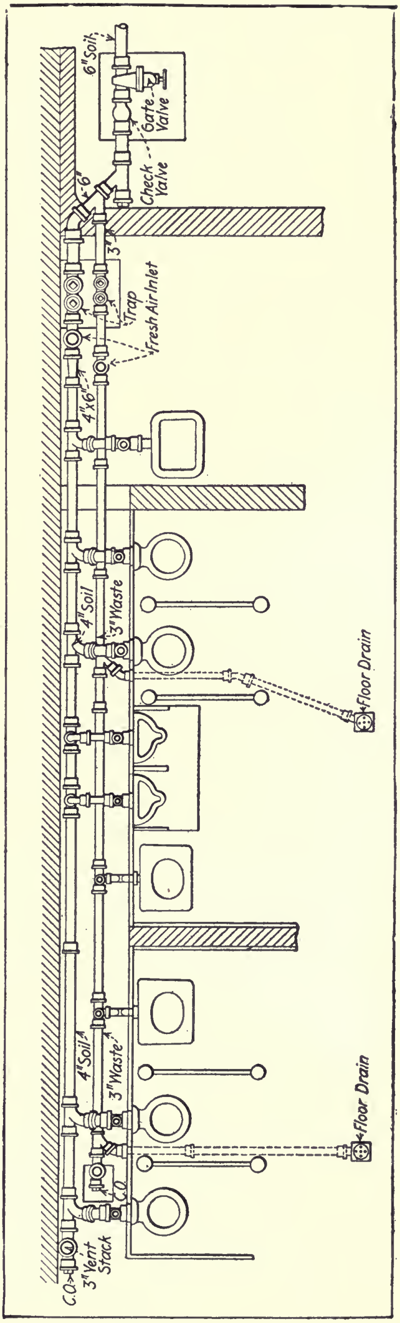


FIG. 187—PLAN OF TOILET ROOM FOR SMALL SCHOOL OR OFFICE

lows: When the lever is raised the spindle turns and raises a plunger by means of a small lever in the chamber. A valve in the plunger is opened by the same action and this allows the water contained in the space above the plunger to escape. Consequently the pressure of water on the two sides of the plunger is unequal and that in the supply pipe is sufficient to raise the plunger to the top of the chamber and keep it there for a short time. The water is meanwhile flowing through the flush pipe to the closet or urinal. Part of the water however finds its way through a small by-pass pipe to the upper part of the plunger valve again and as the upper part is of greater area than the lower side, as soon as the pressure is equalized the valve closes. The time of closing is simply regulated by increasing or decreasing the flow of water through the by-pass pipe. A cap and a set screw are provided for that purpose.

The valve shown in Fig. 194 operates on the same principle and is of much the same construction. The lever or button operating the valve causes the small valve B to open, releasing the pressure in the upper part of the chamber, the water pressure in the hollow part of the plunger causes it to rise and so open a passage to the toilet or urinal. The plunger remains in the open position only until the

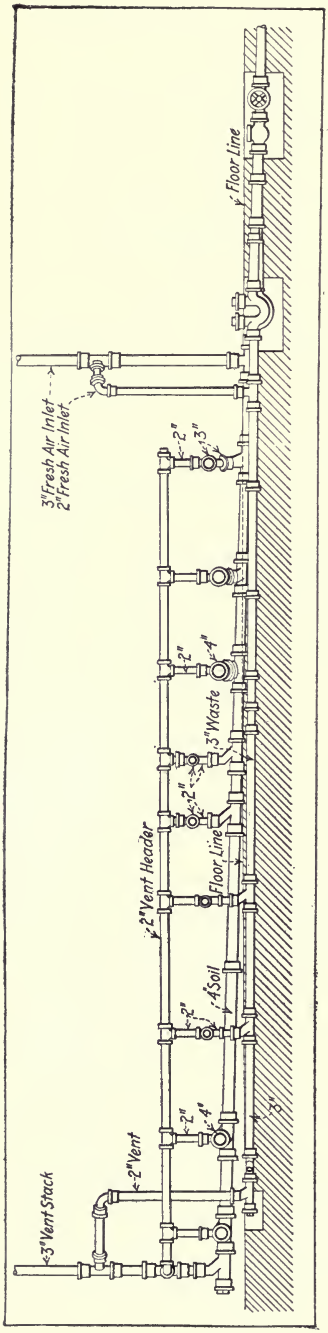


FIG. 188—ELEVATION OF PLUMBING IN SCHOOL TOILET ROOM

pressure has become equalized by the flow through the by-pass C and as in the other valve this time may be regulated by operating the set screw in the passage.

Shower Baths in Schools.

One of the chief problems in designing plumbing equipment for institutions, such as orphan schools, is to provide efficient equipment for bathing the children which will stand the somewhat rough usage to which it may be subjected. While the toilet facilities may be designed along the lines of those commonly used in schools or factories and be installed with individual closets or in ranges according to the particular requirements, it is generally desirable that the bathing facilities will be such that the children are under the direct supervision of the attendants while the process is being conducted.

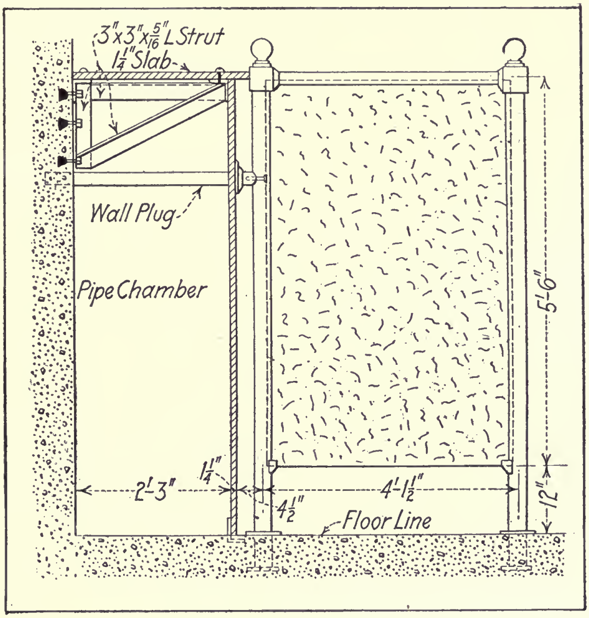


FIG. 189—METHOD OF ERECTING SLATE OR MARBLE PARTITIONS BETWEEN TOILETS

An arrangement such as that shown in Figs. 195 and 196 has proved satisfactory in many cases and it has the recommendation that it is easy to install and not subject to trouble through rough usage or interference with the control valves by the children.

It consists of a depressed bathing floor, constructed of tile or concrete in a manner similar to that employed in a swimming pool but not necessarily deeper than about 6 to 8 in. Over the floor and spaced at suitable intervals, are fitted shower heads supplied from a mixing tank, thermostatically controlled to deliver water at the desired temperature or under the immediate control of the attendant.

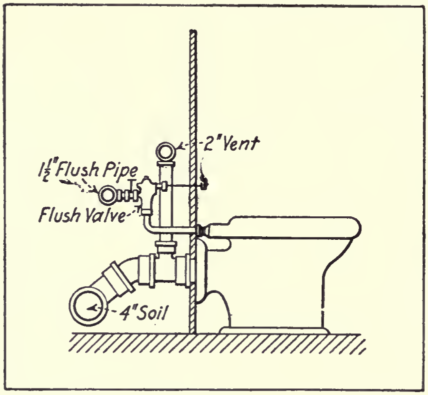


FIG. 190—SOIL AND VENT CONNECTIONS TO SCHOOL CLOSET

Long troughs of stoneware, concrete or porcelain enamelled cast iron are placed along one side and are furnished with faucets so that individual basins may be given the children for a preliminary washing and also to serve for wash-up basins for use at the regular times when it is not intended to use the showers.

The arrangement simplifies the plumbing considerably as only a floor drain of a type which will retain mud and sand and prevent other matter from entering the house drain is required for the shower receptors. The troughs may be connected as shown in Fig. 196 and vented by the loop system. A range of lavatories may be installed if a more elaborate system is desired but as shown a sanitary equipment is afforded at a minimum expense.

The mixing tank may be built from a galvanized-iron expansion tank or a small boiler, or a special arrangement with thermostatic control may be procured. Each shower will pass about 3 or 4 gallons of water per minute when in operation and the sizes of the pipes should be proportioned so that each will have an ample supply. The size of the mixing chamber will be proportioned according to the temperature of the entering water and the temperature at which it is desired to deliver it at the showers. Probably a tank of 20 gallons capacity will be ample in most cases.

Details of Soil, Vent and Waste Piping in Summer Hotel.

The value of first-class plumbing as an inducement for the visitors is recognized by most hotel-keepers and even in hotels situated in remote places, scenery, good hunting and fishing is no longer sufficient to attract and retain patronage. While the building in which the plumbing herein-after described is installed is not of an expensive construction, it has been designed for comfort and the convenience of its patrons and may serve as a typical example of construction in summer hotels and boarding houses. It has been equipped in a thoroughly sanitary manner and each bedroom in the building has been provided either with a lavatory or with a bath room.

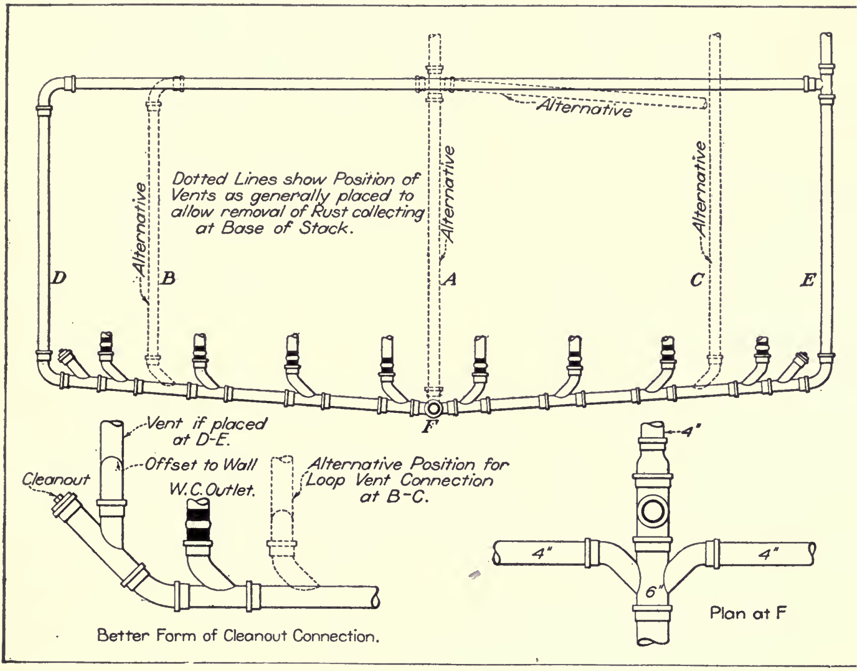

Alternative
Dotted Lines show Position of Vents as generally placed to allow removal of Rust collecting at Base of Stack.
Alternative
Alternative
Alternative
D
B
A
C
E
F
Vent if placed at D-E.
Offset to Wall
Cleanout
W.C. Outlet.
Alternative Position for Loop Vent Connection at B-C.
4"
4"
4"
6"
Plan at F
Better Form of Cleanout Connection.

FIG. 191—ALTERNATIVE METHODS OF CONNECTING A RANGE OF CLOSETS

The proprietor profiting by past experience decided that simplification of the work was desirable and accordingly the piping system was planned to eliminate all unnecessary features but to retain everything that is required to give protection against the entrance of sewer air and to require the minimum of maintaining expense.

This is obvious even on the cellar plan, Fig. 197, which shows the soil pipes run in straight lines in such a manner that the branches are divided into sections to which access may be had from the cleanouts which are provided at the end. As it was designed to have a toilet room and also a laundry in the basement it was necessary that the pipes should be installed beneath the cellar floor and therefore this precaution is a valuable one.

The soil pipe enters the building in 5-in. extra heavy pipe and is then divided into branches running to each side of the building. One of these collects the waste and soil pipes from the toilet room fixtures in the basement as well as the vertical stacks serving the bathrooms on that side of the hotel, while the other is continued in 5-in. pipe and receives the waste from the laundry tubs and also all of the soil stacks from the upper floors on that side of the building.

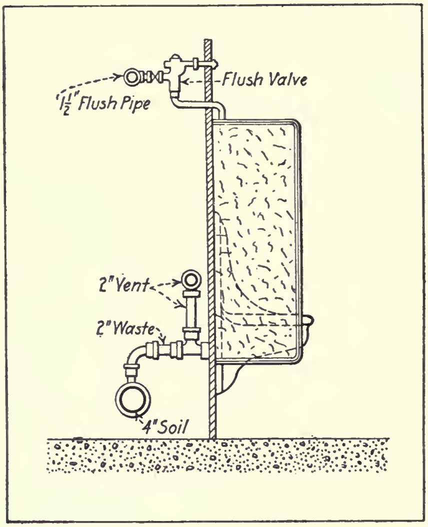


FIG. 192—DETAILS OF URINAL CONNECTIONS

The kitchen is situated in an ell at the rear of the hotel and there is also a bathroom on the second floor of the ell for the use of the servants. Slop sinks are also provided on each of the bedroom floors, while there is a bubbling drinking fountain with a waste receptacle in the main entrance hall. Large wooden sinks are used in the kitchen and in the serving room adjoining. This is according to the desire of the proprietor, who doubtless had in mind the breakage of glasses suffered in previous buildings occupied by him where metal or porcelain sinks were used. Several of the baths are provided with overhead showers and curtains and the water supply to those is through mixing valves of the regular pattern.

The manner in which the fixtures have been vented, with as little complication of piping as possible, is seen in several of the accompanying illustrations. That on stack No. 1 in Fig. 198, which takes care of bathroom and lavatory connections shows how a simplified continuous venting system has been used. The 4-in.

soil pipe which is carried up on the outside wall to the second floor is taken between the joists of that floor and the ceiling of the first floor along the side of the bathroom and is then carried to the next floor and so on to the roof with 4-in. pipe.

The first branch on this horizontal line takes care of the bath tub by a 4 x 2-in. branch and the next one is a Y into which the branch from the closet delivers. As the bedroom lavatory is immediately behind the bath tub connection, the vent pipe in the trap is carried back into the wall, then rising up about 4 ft. it runs along the partition and connects to that coming from the water closet bend. The vent pipe from the water closet is put in in such a manner that it acts as the waste from the lavatory in the bedroom as well, and while this is not regular practice it proves quite satisfactory in this instance as it is seldom that the two fixtures will be discharged simultaneously. The waste from the lavatory also serves to keep the lower part of the 2-in. vent pipe clear of rust and as easy bends are made it may be that this connection is rather desirable.

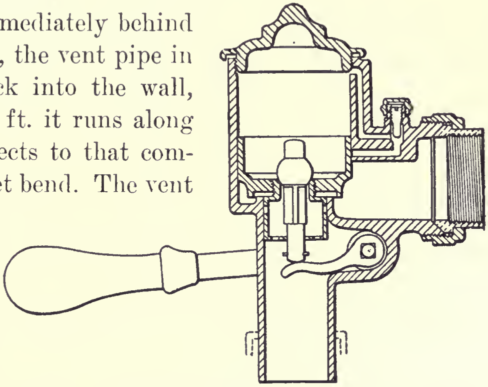


FIG. 193—FLUSH VALVE FOR CLOSETS OR URINALS

A heel inlet at the base of the 4-in. rising stack after it leaves this floor is used to connect the 2-in. vent and the $1\frac{1}{2}$-in. waste which serves the lavatory in the bathroom of this and the floor above. By this means the waste from the lavatory is caused to keep the base of this vent pipe clear also. An interesting feature on the lead bend connection to the water closet is the use of a special brass ferrule which combines the connection to the 4-in. lead bend with that to the 2-in. branch. This is accomplished by having the 2-in. branch cast into the brass ferrule which is long enough to allow a joint to be wiped behind the branch but which is designed so that in a contracted space such as this a saving of several inches is effected. It will be seen that the branch runs parallel to the soil pipe here and that a Y-branch with a $\frac{1}{8}$-in. bend is used to bring it around to the correct position. This allows the bend to be fitted closer to the back wall than it otherwise could have been.

The bath traps are 4-in. lead drum traps and are vented by a lead pipe wiped into the trap at right angles to the waste as it leaves. The details of bathrooms in the rooms immediately over those on the second floor are shown in Fig. 199. The position of the fixtures is duplicated, but as the stack rises at the opposite end of the room the manner of making the connections is a little different. The 2-in. vent stack is seen as it is carried up from the lead bend below and connected into the 4-in. soil pipe over the ceiling of this third-floor bathroom and into which the continuous vent of the bath and the bedroom lavatories is connected. It will also be seen that the bathroom lavatory on this floor enters the 4-in. stack by a 4 x 2-in. sanitary tee and that the vent is continuous in this instance also, connecting into the 2-in. line which was carried from the lavatory below it.

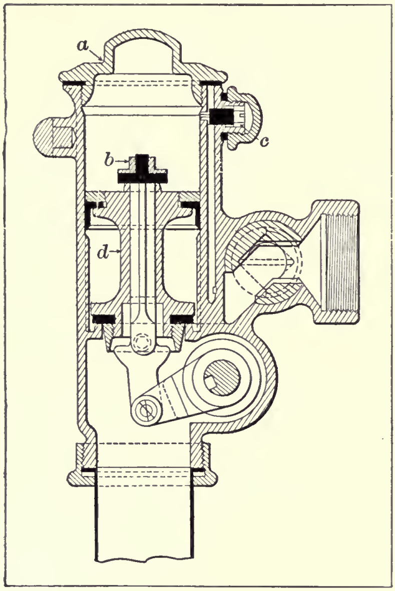


FIG. 194—ANOTHER TYPE OF FLUSH VALVE

The water closet on this floor is not vented, as it is placed close to the main stack and also because of its having a 2-in. extension to the bath waste and lavatory which continues as a vent in 1½-in. pipe. The pipe after leaving the reducing connection at the 4-in. Y serving the water closet is carried in 2-in. galvanized pipe with long sweep recessed fittings and the lavatory waste tee is the regular pattern of drainage fitting. The 4-in. pipe after the connections are made back into it is carried directly through the roof.

A method of making connections for vent pipes which is more regular in its design is seen on stack No. 5, illustrated in Fig. 200. In this case the 4-in. line rises directly from the horizontal line in the toilet in the basement. A 4 x 4-in. sanitary tee is taken off at each floor to serve each of the bathrooms on the line and the closet on the second floor is vented by means of a 2-in. pipe wiped into the bend. The closet on the third floor is not vented owing to its proximity to the stack and the fact that no fixtures are connected above it. The waste from each of the bathrooms enters the branch to the closet by means of a 4 x 2-in. Y and the pipes are then carried in 1½-in. galvanized iron to serve the bath and lavatory waste.

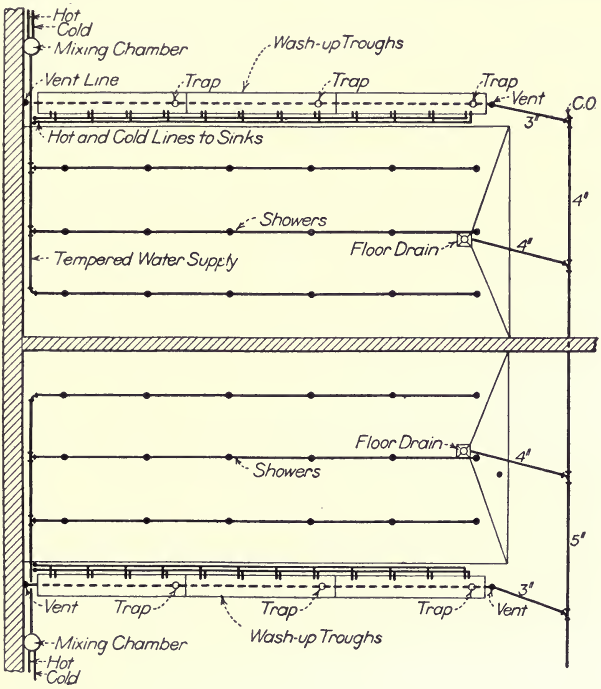


FIG. 195—PLAN OF SHOWER BATH SHOWING WATER SUPPLY AND WASTE LINES

Lead drum traps are used in each of the bath rooms and both are vented back into the line as shown. There are a considerable number of 4-in. vent pipes projecting through the roof and as it is of a continuous pitch to the rear of the building the plumber responsible for the installing of the work showed some originality and also secured a neat appearance by grading the pieces which were calked into the vent pipes after they had passed through the metal roof so that the top of each of the stacks is on a level.

The water supply to the hotel is brought from the main supply to the village and a pressure of some 80 lb. per sq. in. is available. The distribution is by means of galvanized-iron pipes carried up in the most direct manner in each case and controlled by a separate valve to each bathroom. A section of the piping system is seen in Fig. 201, which shows the method of installing the heating boiler. In the illustration the cold-water supply is seen sending off the branches to several of the bathrooms and bedrooms before it enters the boiler. The supplies, both hot and cold, are taken off as nearly as possible at one point and each of the stop cocks are labeled so that it is an easy matter to find the supply to any particular part of the building.

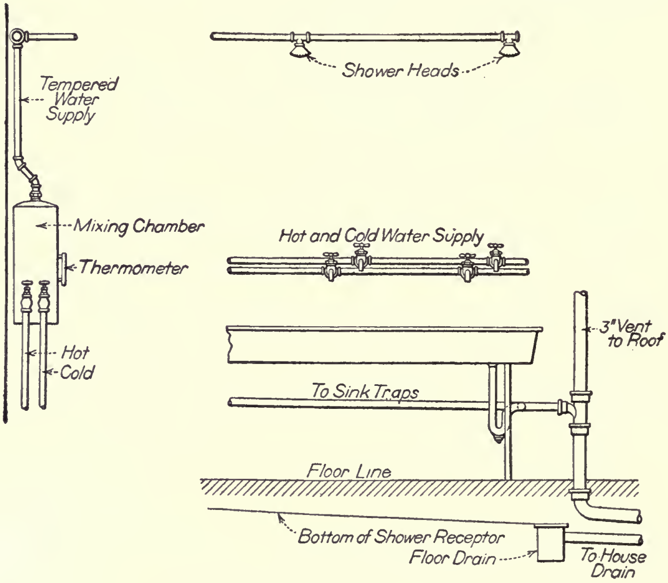


FIG. 196—DETAILS OF WASH-UP SINKS AND SHOWER CONNECTIONS

The manner of connecting up the storage tank is designed to afford a quick circulation from the tank heater to the boiler. The branches to the fixtures which are comparatively far away from the boiler are provided with a circulating pipe so that hot water is immediately available and as these are the kitchen, serving room and laundry supplies, this provision is in any case advisable.

A Layout of Waste, Soil and Vent Pipes and Water Supply for Plumbing in a Bungalow.

As the chief recommendation of the bungalow type of house is its cheapness and ease of construction and "operation," if the word may be used, it is but right that the plumbing of such a building should have corresponding features. It should first of all be safe. Then it should be as simple as it can be made to be efficient. Simple or complex, the workmanship should be good and the fixtures substantial rather than ornate.

The requirements are not hard to meet. There are no hard problems to be overcome in the design and construction of the work. If the fixtures are all on one floor, and they will be if the bungalow is of the regular type, the complicated venting systems necessary for safety in a higher building with fixtures on several floors may often be done away with or at least greatly simplified. The reason for this is that there will be little chance of traps being unsealed, as the flow to the sewer is from a level that will not create a great rush of air behind or in front of the discharge.

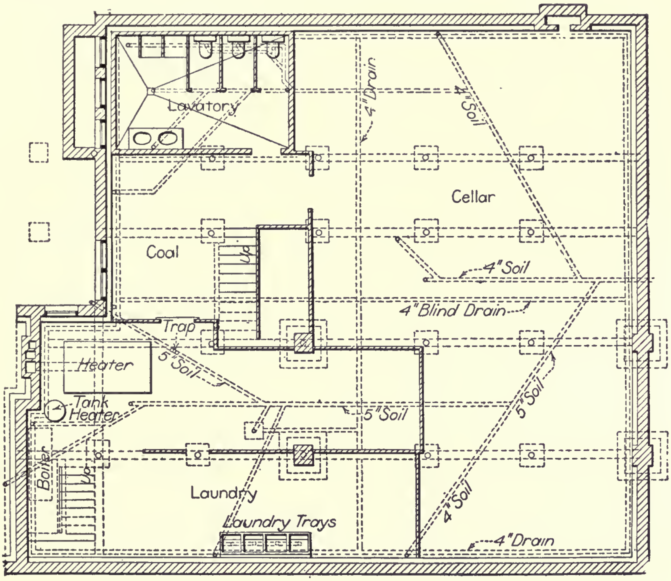


FIG. 197—PLAN OF BASEMENT OF SUMMER HOTEL

Therefore, all that must be guarded against is the chance of unsealing a trap through the siphonic action of the water flowing in a branch line if more than one fixture is connected to it. This is indicated in the illustration in Fig. 202, where a lavatory and bath tub are shown connected to one pipe leading into the vertical soil pipe.

In this case it is better to ventilate both fixture traps, as is shown in Figs. 203, 204 and 205, as then not any of the seals will be disturbed by the discharge of any one fixture on the line. The construction is simple and the continuous venting principle upon which the work is constructed is accepted as standard by practically all sanitary authorities. The location of the fixtures is shown in the plan in Fig. 203, while Fig. 204 shows a section through the bathroom from A to B. In this illustration it is seen that the 4-in. lead bend connecting the water closet is connected directly to the vertical stack, and as it is the highest fixture on the line and not subject to any siphonic influence by reason of large discharges of water from other fixtures it is not necessary to re-vent it.

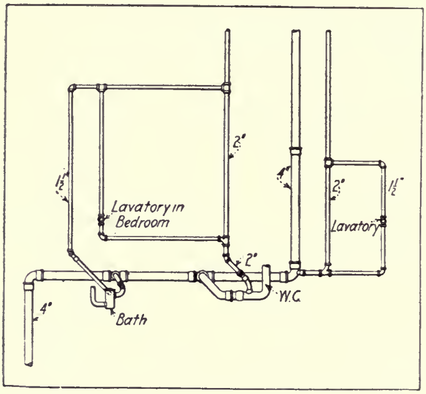


FIG. 198—ELEVATION OF STACK NO. 1 AT SECOND FLOOR SHOWING SIMPLIFIED VENT CONNECTIONS

The waste pipes from the rest of the fixtures, namely, the bath tub, lavatory, sink and laundry tubs are connected into a 2-in. cast-iron pipe carried along in the basement, if there is one, or under the floor if not. A cleanout is left at the end of the line so as to give access to the pipe should it become choked at any time. The connections from the laundry tubs, sink and lavatory enter the 2-in. pipe by 2 x 2-in. sanitary tees set with the branches looking upward. The connection for the bath tub is made to a 2 x 2-in. sanitary tee at the end of the line and into the end hub of which the cleanout is calked.

The waste pipe branches from each fixture are preferably constructed of galvanized wrought iron and the traps connect to long branch tees placed at the correct height to receive them. The waste for the lavatory may be 1½ in. in diameter and the others of 2-in. pipe. If the traps are of lead they should be connected to the tees by means of screwed brass ferrules wiped to the trap, and if they are of brass or iron by bushings properly connected by threaded joints. If the traps are too light in weight to stand a thread they should be connected by means of a thoroughly soldered joint between the bushing and the trap.

The section through CD in Fig. 205 shows the bath waste and vent connection, which is also made on the continuous principle. A 2-in. wrought-iron pipe is carried from the cast-iron tee on the horizontal line, and a long branch tee is caused to turn up to receive the vertical waste pipe and continuous vent as shown. At the proper height another tee of the same style receives the half-S lead trap fitted with a screwed ferrule, as already described.

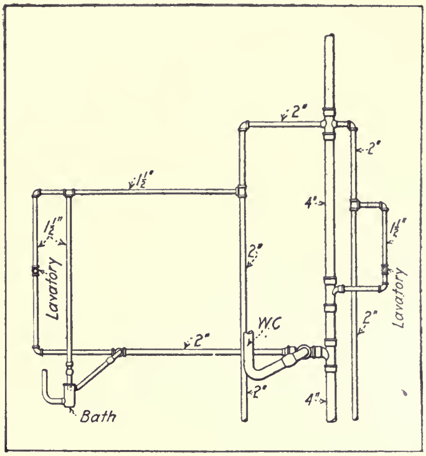


FIG. 199—ELEVATION OF STACK NO. 1 AT THIRD FLOOR WITH WASTE AND VENT CONNECTIONS

The vent pipe is carried to a height convenient for fitting the horizontal pipe which will carry the vent across the bathroom to the partition against which the lavatory is set, and to secure that a good pitch may be gained, if it is not practicable to use a 45-degree elbow, it is well to use two 90-degree elbows to make the turn. By doing this the pitch may be made anything that is required, and the same may be done at the end of the horizontal pipe running above the lavatory and receiving the vent connections from the tubs and sink as well as the lavatory.

The 4-in. stack, after it has received the branch from the water closet, is carried upward, and at the point where it is to receive the horizontal vent pipe from the fixtures a 4 x 2-in. tapped tee is placed. Then the pipe is carried upward and through the roof at a point clear of any roof windows or openings by about 10 ft.

To connect the soil pipe to the sewer it may be necessary to carry the pipe overhead in a basement. In such an event it should be carefully supported at each hub by iron hangers. If it can be carried near the ground level brick piers may be used with satisfaction, but in any case it should be carefully graded and supported.

If the pipe discharges into a septic tank a house trap will not be required. If a house trap is demanded when the connection is made to a public or private sewer a vent pipe should be placed to allow fresh air to enter at a point just inside the house trap. It should never be connected to the trap by the hub connection above the seal. This should be used for a cleanout and a special tee should be inserted behind the trap to receive the fresh-air connection. If connected directly to the trap there is a possibility of the seal freezing in cold weather or of evaporating by long exposure in hot weather when the discharges from the fixtures may be infrequent or discontinued as at vacation times, or when the house is not occupied.

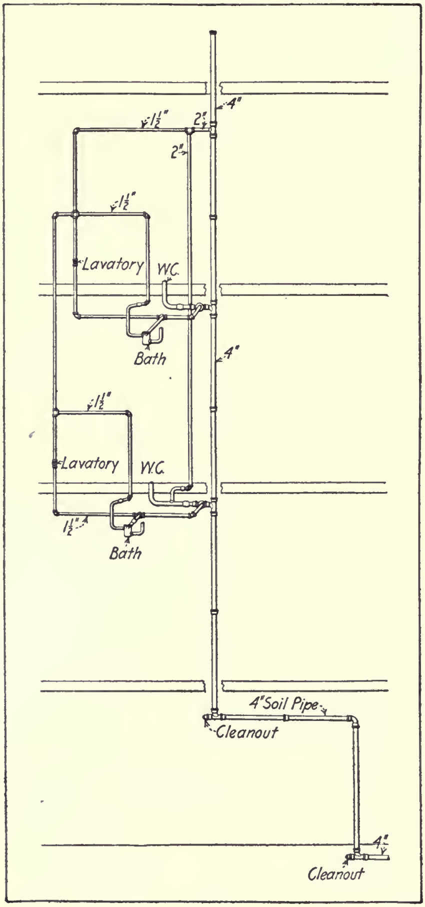


FIG. 200—ELEVATION OF STACK NO. 5, SHOWING VENT AND WASTE CONNECTIONS

The water supply to the fixtures in such a building is a simple proposition. If there is a basement beneath the bathroom the pipes may be conveniently fixed on the ceiling, with the hot and cold-supply pipes supported by adjustable galvanized-iron hangers. If these are used, and the pipes are fixed parallel to each other, and a few inches below the joints, the branches to each fixture may be taken off by tees set at an angle of 45 degrees, with 45-degree elbows to bring the branch to the level again. Thus the hot-supply branch may cross the cold-supply main or vice versa without interfering with the pitch necessary to drain it.

Stop and waste cocks placed at the branch connections are useful in that the supply to any one fixture may be closed without interfering with the others. The arrangement of piping for the fixtures shown in the plan in Fig. 203 is illustrated in Fig. 206. The vertical branches may be taken up in the partitions to the required height to supply the lavatory, sink and laundry tubs or they may be taken through the floor and supplied through nickel-plated connections to the faucets.

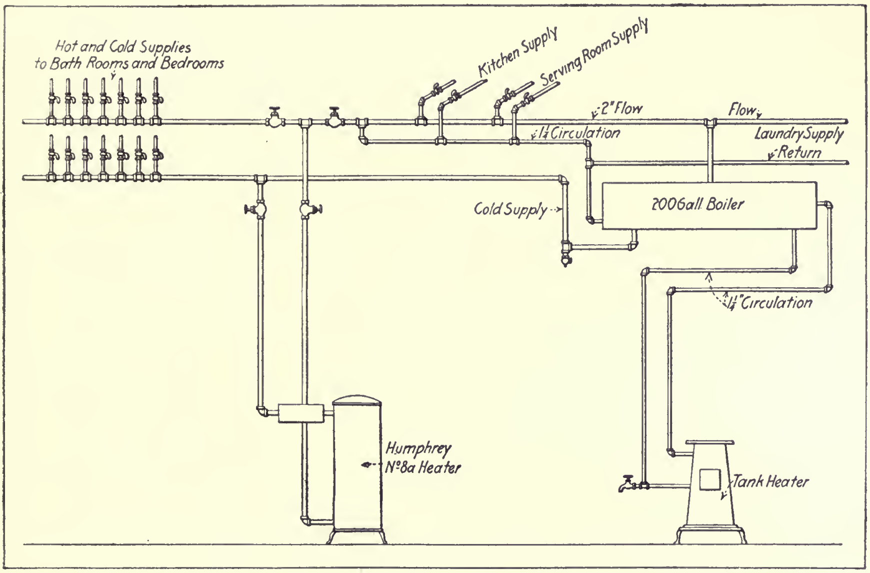


FIG. 201—HOT AND COLD-WATER DISTRIBUTING CONNECTIONS

If a basement is not available it may be advisable to run the bathroom supply pipes on the baseboard. If this is carefully done the appearance need not be unsightly, and it is common to use nickel-plated brass pipe in such cases, especially if the fixtures are of a high grade. Then the branch connections may be made with crossovers to preserve good alignment of the pipes and to insure that the pitch will be equal all around the room.

Plumbing in a Moderate Price Cottage With Unnecessary Features of Ventilating and Waste-Pipe System Eliminated.

The question to be considered chiefly in designing the plumbing equipment in a cottage where city regulations do not enforce strict obedience to certain requirements in construction is that of economy. The word economy must not be construed to mean mere cheapness, however, but should rather spell efficiency at the lowest cost.

To secure this efficiency the method of construction adopted should be such as to simplify the piping layout while not sacrificing any of the safeguards that must be provided against the entrance of sewer air, the proper working of the system and the easy upkeep of the fixtures. In other words, it should be ascertained what can be done without as well as what must be done.

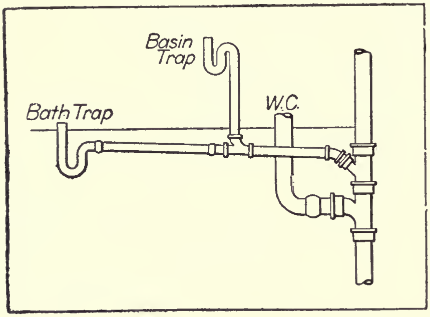


FIG. 202—FIXTURES CONNECTED TO A BRANCH LINE WITHOUT PROVISION FOR VENTILATION OF TRAPS

The price that the customer is willing to pay must in a measure determine the quality of the work, but it should never limit the safeguards that must be included in the design. The illustration in Fig. 207 of a typical installation of plumbing in a two-story and basement cottage may illustrate this clearly.

No account need be taken of the quality of the fixtures in this connection. It is clear that these should be of the best quality consistent with the use to which they are to be put, the design of the rest of the building and the tastes of the owner. The long service given by a good grade of material dictates that real economy is secured in the end when a fair price is allowed for this part of the work.

In the construction of the soil and vent piping, however, it is quite possible to make some saving over the cost of installing a similar number of fixtures in a larger building. In the first place, there is less possibility of siphoning fixture traps in a low building than there is in a high one with other fixtures draining into the same soil pipe at a higher level, and therefore much of the venting that is absolutely necessary in the large building can not only be safely omitted, but the job will be really more efficient without it. This saving is only secured with safety when the design is well worked out, however, and a study of the illustration will show this.

In the first place, the illustration in Fig. 207 shows a house trap with a fresh-air inlet installed in the same manner as it would be in a large building. If the house drain does not deliver into a sewer, but is connected to a septic tank or to a private drain delivering into a brook or pond, as is common in country districts, this trap may safely be omitted. In fact, if a septic tank is used and no means of venting the pipe between the house trap and the inlet to the septic tank is provided, it is conceivable that an obstruction to the flow would be made by the air trapped in the part between the seal of the house trap and the submerged inlet to the septic tank.

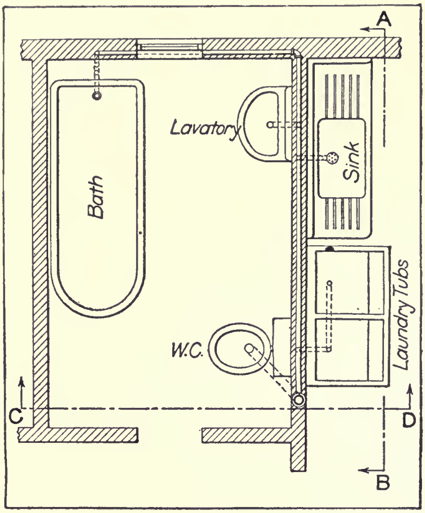


FIG. 203—PLAN OF KITCHEN AND BATH ROOM FOR A BUNGALOW

The advisability of leaving the trap off where a connection is made to a public sewer is open to question. There are good arguments on both sides, but an effective one against the discontinuance of the trap is offered when it has been found that in extremely cold climates the public sewers have become frozen by the excess of cold air allowed to pass through them by the great number of open ends afforded by the untrapped house drains.

Taking the internal construction of the plumbing, it will be seen that with the fixtures placed as in this house it is more economical in every way to erect two soil stacks than one. By doing this the branches to the fixtures are short and the number and length of the vent pipes and branches are reduced to the minimum.

Two of the fixtures, namely, the bath tub and the W. C., having no waste connection entering the stack above them, may safely be left without any re-vent connection, and in both cases the fixture traps are within safe distance of the vertical main vent stack. For a house of this size a 4-in. house drain will give good service. The house drain may be installed so that it will run above the cellar floor and still drain the laundry tubs or other fixtures in the basement if these fixtures are rightly placed or if they can be placed on a platform raised a little above the floor level.

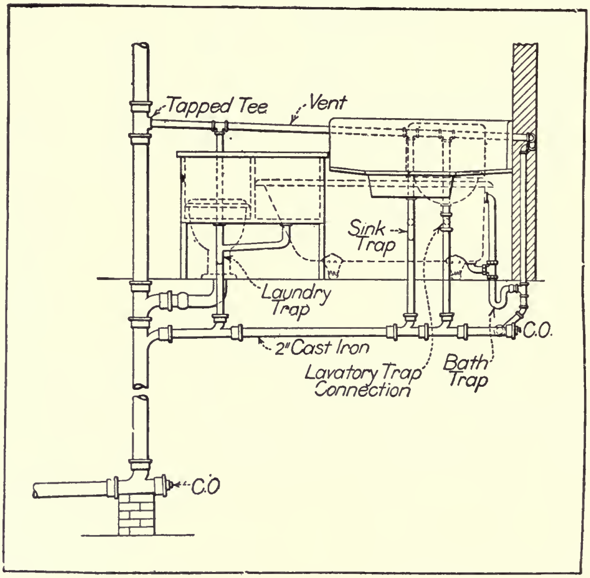


FIG. 204—SECTION THROUGH A B IN FIG. 203, SHOWING WASTE AND VENT LINES FROM FIXTURES

If the floor is of concrete and it is necessary that the pipe be run beneath it, a bricked up trench should be provided if the appropriation will admit of it. If not, the trap and cleanout at least should be accessible through brick pits with iron or wooden covers and there should be as few bends under the floor as possible. If a branch fitting can be used to make a turn instead of a bend, then a cleanout may be calked in the end hub and access will be easy to clear the pipe of grease or other obstruction should it ever occur. In the event of such cleanouts being provided it should be endeavored to place them where other fixtures, heating furnaces, coal bins or partitions will not interfere with the means of access.

The riser connections should be made either with Y's or long pattern T Y's. The first are preferable, and to bring the pipe to the required position a ⅛ bend may be calked into the branch of the Y. The standard size of pipe to use for the W. C. stack is 4 in., but on occasion it may be advisable to use 3-in. pipe here. In the case illustrated the pipe is without any lateral change in direction, and there are no other fixtures to take care of. Therefore, it would in most cases be perfectly safe to use 3-in. pipe if it was advantageous to do so for any reason connected with the building construction. Such reasons may be strong if to accommodate the 4-in. soil pipe a box has to be constructed or a partition of special width erected. Economy may also be effected in such cases by making the pipe of galvanized wrought iron rather than of cast iron. There will be fewer joints to make and the pipe will occupy less space than one of the same diameter in cast iron will.

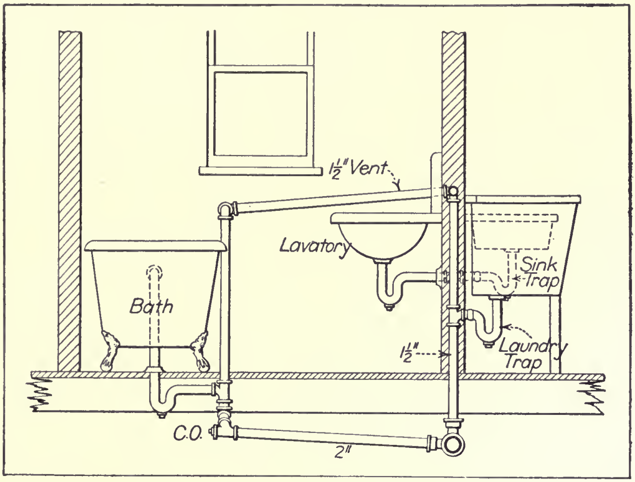


FIG. 205—SECTION OF WASTE AND VENT PIPES THROUGH C D IN FIG. 203

The diameter of the pipe necessary to serve the bathtub, sink, lavatory, and slop sink is 3 in. This may be made either of cast iron or wrought iron at the option of the plumber. The cast iron is somewhat easier to install where there are so many inlets to the vertical pipe and for this reason it may be preferable, as the quality of the two is on a par for work of this class. The branches to the fixtures should be made through sanitary tees. The space between the floor and the ceiling will not as a rule permit of Y's and ⅛ bends being used, but the sanitary tees will give satisfactory service in this position.

It is necessary to vent the traps of the drip sink, the laundry tubs, the kitchen sink, the slop sink and the lavatory. In a 3-in. pipe the discharge from a slop sink or a bathtub is sufficient to fill the vertical pipe with a swirling column of water falling with a high velocity as the result of the pressure behind it. This exhausts the air very completely and therefore there is a vacuum formed behind the falling column which would unseal the traps in quick time if means were not provided for the easy replacement of the air exhausted. The same care must be observed to protect the seals on the drain side of the descending column of water, but in this case the air in front of the column is being compressed and must find outlet somewhere. If there are no open ends and if the length of the house drain is considerable to the fresh-air inlet or to the open end at the sewer or septic tank this pressure will probably be sufficient to blow the water out of the fixture traps. Therefore, it will be seen that it is not possible to entirely eliminate vent pipes, although these may be simplified as much as possible.

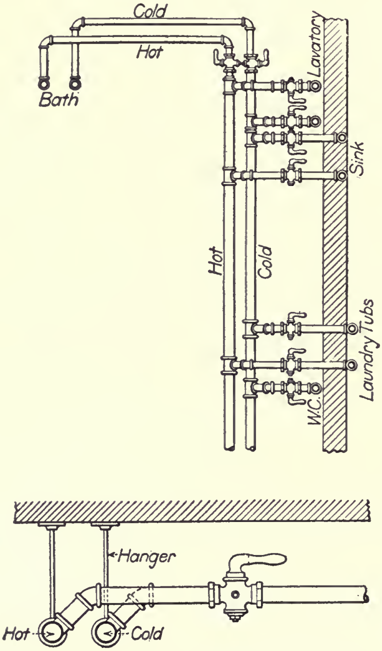


FIG. 206—PLAN OF WATER SUPPLY PIPES WITH DETAIL OF BRANCH CONNECTION

The plan shows that the laundry tubs have been connected to the horizontal 4-in. pipe under the basement floor, and that the drip sink trap discharges into a sanitary tee at the base of the 3-in stack. As it is desirable that a vent stack should have a connection with the soil pipes at its base it is therefore economical and also first-class practice to use the vent of the drip sink as the lower part of the vent line for the other fixtures. The vent from the laundry is easily connected through a 45-degree branch fitting so that no rust may collect in it and then the vent pipe is continued upward to receive the vent connection from the kitchen sink.

The waste line of the slop sink is of 3 in. diameter, and it is probably best to make this of wrought iron, connecting the slop sink with a lead bend connected to the wrought iron by means of a brass screwed nipple. It may be well to mention that the fitting known as a brass waste bushing is convenient to use for such connections and the lead pipe may then be passed through it so that there is no brass exposed to the action of the water or waste matters passing through it. Such a connecting ferrule is shown in Fig. 208.

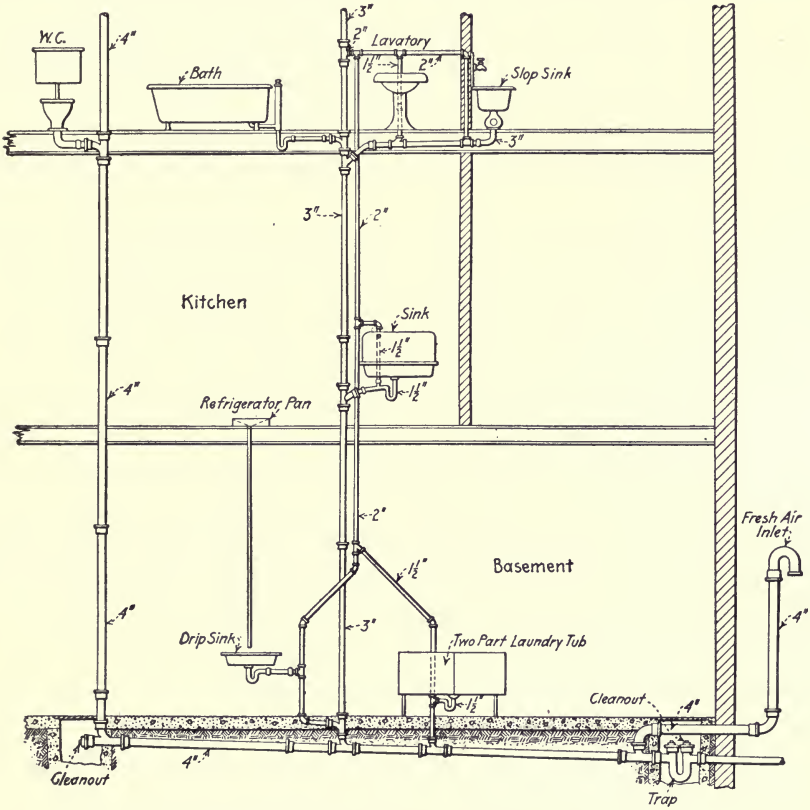


FIG. 207—ELEVATION OF TYPICAL COTTAGE PLUMBING SYSTEM

A 3-in.× 2-in. tee screwed on the end of the wrought-iron pipe may be used satisfactorily for the vent connection, and as the lavatory trap will be vented on the continuous plan the waste pipes may be put right in and the vent pipes connected to the stack at a level high enough to insure that no waste water can pass through them in the event of the regular path being obstructed. The plan shows the vent pipe carried to a level above the top of the lavatory, but in some cases it may be advisable to keep this down so that any water backing up in the vent pipe would be noticed before it could pass to the waste stack through the vent connection and yet the fixture could not overflow. This, however, is a detail which may be overlooked without much harm in a single house, as there would be little chance of continued use of a fixture at a level high enough to cause an overflow when it was known that the use would cause a nuisance at a lower level.

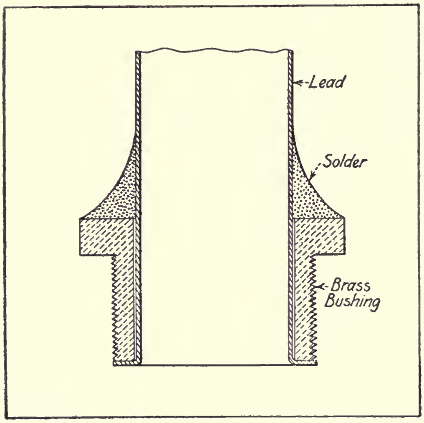


FIG. 208—SATISFACTORY METHOD OF CONNECTING LEAD AND WROUGHT IRON PIPE

The bathtub connection is made to the 3-in. stack through a regular half-S trap. There is no need for re-venting here any more than there is at the W. C., as the fixture is the highest on the line. It will be necessary to make connections between the various vent pipes and fixture traps at one or more places with right and left couplings or with unions. If unions are used those with ground metal faces should be selected. On no account should a union with a lead or soft packing be selected, as there will be a liability to leakage should the packing shrink. The vent stacks, after the top connection has been made, should be carried through the roof in as straight lines as possible, and so that they discharge at a point above any windows or roof openings and far enough away from them to avoid any chance of odors being blown into the rooms.

If nickel-plated traps are used at the lavatory, sink and laundry tubs, the connection to the wrought-iron tee should be made by means of a brass bushing. If the traps are heavy enough they may be threaded and screwed into the bushing in the same manner as a piece of pipe, but if not then the end of the trap should be carefully tinned and the bushing connected to the trap by sweating the connection full of soft solder. Slip joints on the drain side of a trap should never be used, as it is only a question of time before the packing will dry out and allow a leak of drain air to occur.

The refrigerator pan may be made of wood and about 1 ft. square. It should be constructed so that it will have its outlet at the center with a sharp pitch from the sides, so that the walls of the box must be from 2 to 3 in. high. The connection may be made to the copper or lead lining with a piece of lead pipe and a brass solder nipple at the end of the pipe may be connected to a

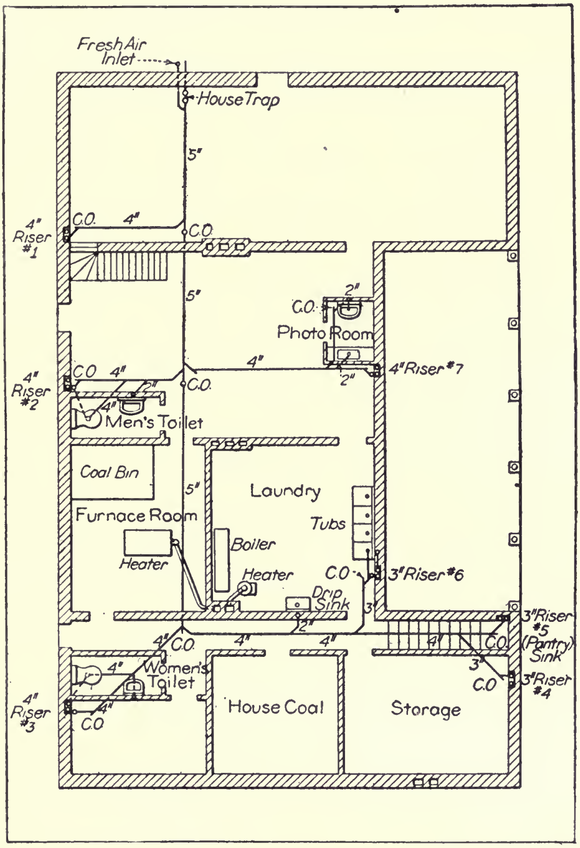


FIG. 209—PLAN OF BASEMENT OF A COUNTRY HOUSE, SHOWING ARRANGEMENT OF FIXTURES AND HOUSE DRAINS

wrought-iron pipe which can deliver over the top of the drip sink in the basement.

The drip sink need not be large, but should be firmly attached to the wall at a height sufficient to secure a good connection to the waste pipe. A sink of galvanized cast iron will give first-class service for this purpose. The trap may be 1¼ in. in diameter if desired, but preferably should be 1½ in. The waste from the pan may be 1 in. in diameter and if any turns are necessary cleanouts should be used.

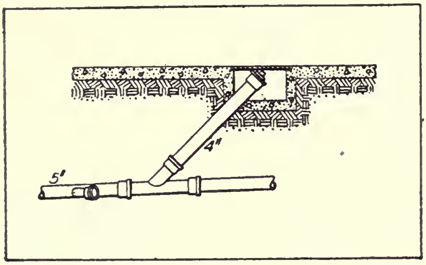


FIG. 210—METHOD OF FITTING CLEANOUTS IN DRAINS UNDER FLOOR

The water supply to the fixtures must be proportioned according to the pressure available. If it is at all high a pipe of ¾ in. diameter will probably supply all of them abundantly. It may be carried up alongside of the 3-in. waste pipe and the branches to the various fixtures connected under the floors, or if a separate control for each fixture is desired separate branches may be taken up from the basement. The latter is the more expensive way, but if a water table is used it gives the owner complete control over all of the fixtures and there is little chance of the wrong stopcock being closed if all are together on a board and properly tagged. When pipes are laid under floors that would cause damage and expense to take up for any repair it is well to make them of brass. Then they are at least immune to a great extent from filling up with corrosion as iron pipe sometimes does. If the appropriation will admit it, control valves should be placed on all of the supplies to the fixtures. Angle valves on the lavatory supplies and neat compression valves with wheel handles on the closet and bathtub supplies look well and afford a ready means of regulating the flow to a desirable point, as well as of closing the supply when repairs are necessary. The hot-water supply in such a building is a simple affair, and generally consists of a pipe taken from the top connection of the boiler placed in the kitchen and then following the line of the cold-water pipes to the fixtures.

As the runs are invariably short, little is to be gained by making a circulating loop, and when this is done it merely consists of connecting a pipe at the most convenient place at the last fixture, taking care that there are no low spots in the piping and

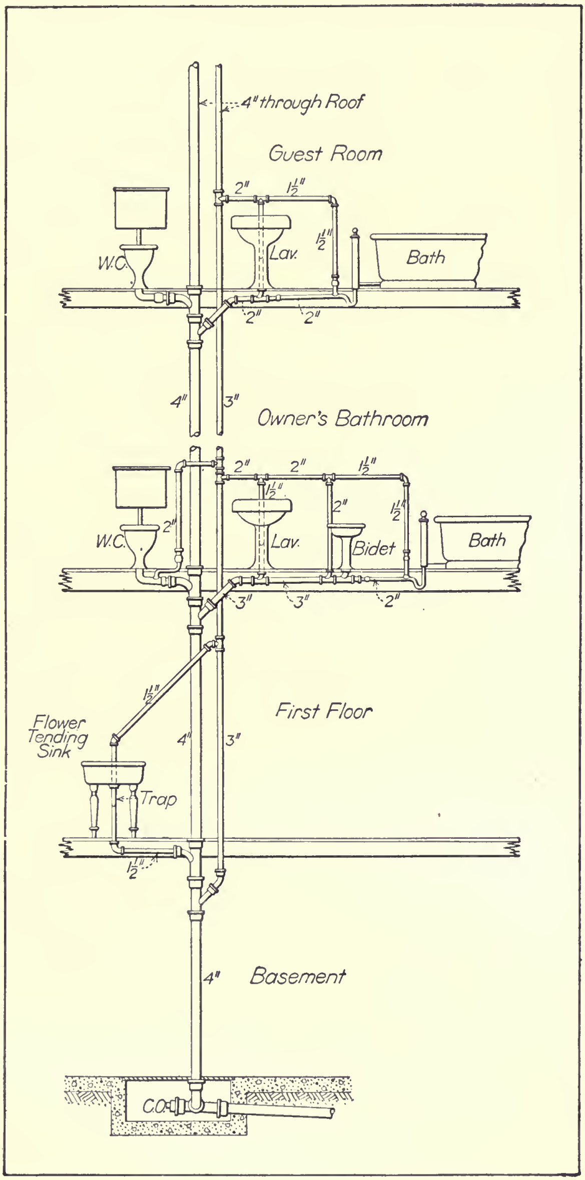


FIG. 211—ELEVATION OF STACK NO. 1 WITH CONNECTIONS FROM FIXTURES ON VARIOUS FLOORS

providing for the escape of air by connecting the said fixture so that the air will escape each time water is drawn. Then the circulating pipe is carried down to the kitchen and connected to the lower tapping of the boiler or to a tee on the return connection to the kitchen range. The circulating pipe may generally be made one size less than the supply with advantage.

Equipment of a Country Residence—Details of Soil, Vent and Waste Connections to Modern High-Grade Fixtures, With Methods of Distributing Hot and Cold Water Supply.

When plumbing is installed in a modern country residence large enough to deserve the classification of a "mansion" it is, as a rule, of the highest class, and designed with an eye to permanence and thorough efficiency. Therefore, such work offers every opportunity for the exercise of engineering ability and skill in construction, and is accordingly worthy of special study.

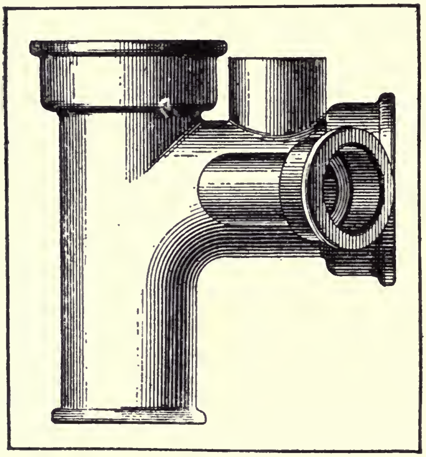


FIG. 212—SANITARY TEE WITH WASTE AND VENT CONNECTIONS

While the architectural features of such a building do not of necessity control the principles upon which the plumbing work must be constructed they always control the application. For instance, a building of a rambling character may require that the plumbing system be divided into several sections, so that it may be drained without unduly long horizontal runs of soil and waste pipe. Otherwise, such pipes might become stopped frequently throught the precipitation of solid matters carried owing to the sluggish flow consequent upon long runs and insufficient pitch.

A country house of a very common type is illustrated in the plan in Fig. 209. This is a somewhat large and roomy residence of brick construction, with a wing at either end. One of the wings contains the kitchen and servants' quarters; the other, public rooms on the first floor and bedrooms on the second and third or attic floors. The laundry is situated in the basement, as are also toilet rooms for men and women servants, and a photographic room with a special sink and a lavatory. Hot water is supplied by a regular tank heater connected with a horizontal boiler of 200 gallons capacity.

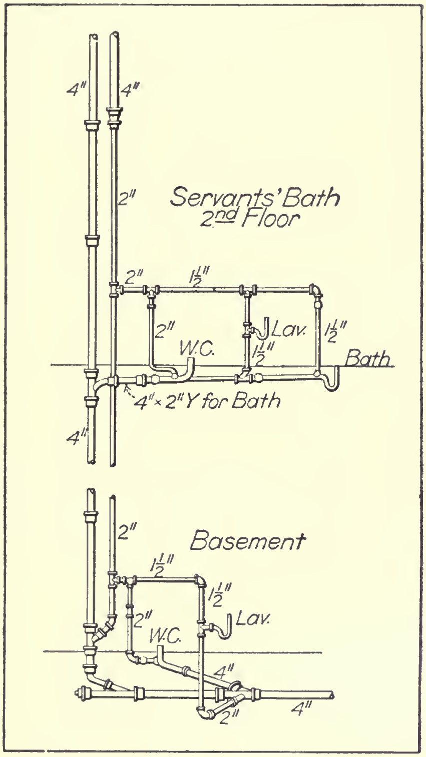


FIG. 213—ELEVATION OF STACK NO. 3, SHOWING CONNECTIONS TO BATHROOM AND BASEMENT TOILET ROOM

The sewage from the house and outbuildings is discharged to a septic tank situated at some distance from the house and delivering into a sub-surface disposal bed in two parts with control valves.

The floor of the basement is of concrete, and as there are fixtures at the opposite end to which the house drain is carried to connect with the septic tank, the soil and waste pipe had of necessity to be carried under the floor. So as to provide easy access to the house drain it was carried in a straight line from the house trap to the point where it was necessary to connect the branch pipes serving the farthest fixtures. The plan will show that the intervening connections were made by means of long Y fittings, and that cleanout openings were provided on the main pipe behind these branches. Thus a stoppage at any of them could be reached without trouble.

These cleanout openings take the form of a long Y set with the branch looking up to the floor. Then it is extended until the branch pipe reaches almost to the floor level, when a cleanout screw is calked into the hub and an access plate is left in the floor, as shown in Fig. 210. At the end of the straight run of house drain a cleanout is placed. This is also provided with an access plate in the floor, as indeed are all of the cleanouts shown at the foot of the stacks. This is good practice, and often saves great expense should any article be inadvertently allowed to pass into the pipe and a stoppage occur.

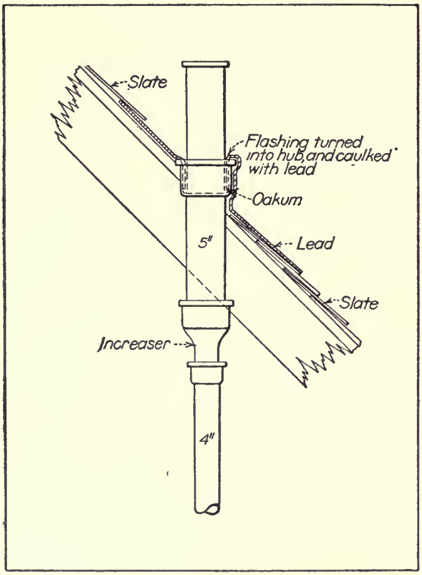


FIG. 214—ROOF CONNECTION FOR SOIL AND VENT PIPES

In cases where there are no fixtures to connect in the basement it may be preferable to carry the soil pipes on the basement walls or suspended from the ceiling. When this is done they are accessible for repair and the cleanouts are also more accessible, but the practicability of carrying such a long run of piping as is shown in the accompanying plan otherwise than under the floor is doubtful in most cases. If it is desired to provide the greatest safeguard against future trouble a brick or concrete trench should be constructed in which to carry the soil pipes. This may also be used for the main water pipes, if for any reason it is desired to conceal them.

A point worth close attention in such work is the protection of lead or wrought-iron pipe from the effect of concrete, especially cinder concrete. Cast iron does not seem to be affected appreciably by contact with lime, moist cinders or cement concrete, but wrought iron and steel, or lead pipe are corroded to a serious extent and should always be protected by a covering of asphalt.

The vertical soil and waste pipes should not be connected directly into the horizontal branches by means of bends. The plan shows that all of these enter the branch of a Y, of which the end hub is provided with a screw cleanout. Thus access is possible throughout the part of the system covered by the concrete at its most vulnerable points. Should it be necessary to carry all or any part of the soil and waste pipe in a horizontal direction above the floor level the pipe should be supported at every hub either by a heavy hanger or by a pier built of brick or constructed with an iron band encircling the pipe and held firmly by a substantial vertical support of iron pipe. Such hangers are shown in some of the detail drawings accompanying the plan.

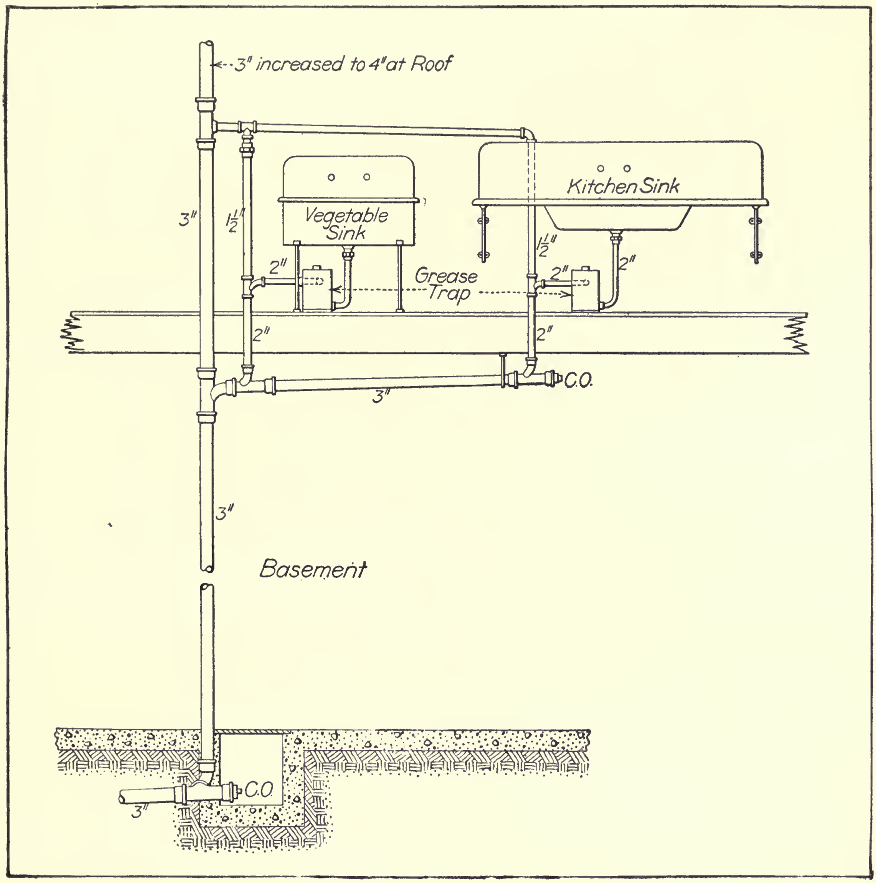


FIG. 215—ELEVATION OF STACK NO. 4 SERVING KITCHEN FIXTURES. GREASE TRAPS ARE USED ON SINKS

The main house trap is placed just inside the wall and to a tee calked in the main house drain behind it is connected a 4-in. pipe carried to the outside and finished above the ground line with a return bend. Cleanouts are calked into the hubs of the trap and proper access plates are left in the floor above these. The fresh-air inlet may be taken to a point at some distance from the house to prevent any odors from being carried back when fixtures are discharged. Instead of a return bend the pipe may finish in a wall, or some ornamental feature of the surroundings in which an iron box with proper means of connecting the pipe can be placed.

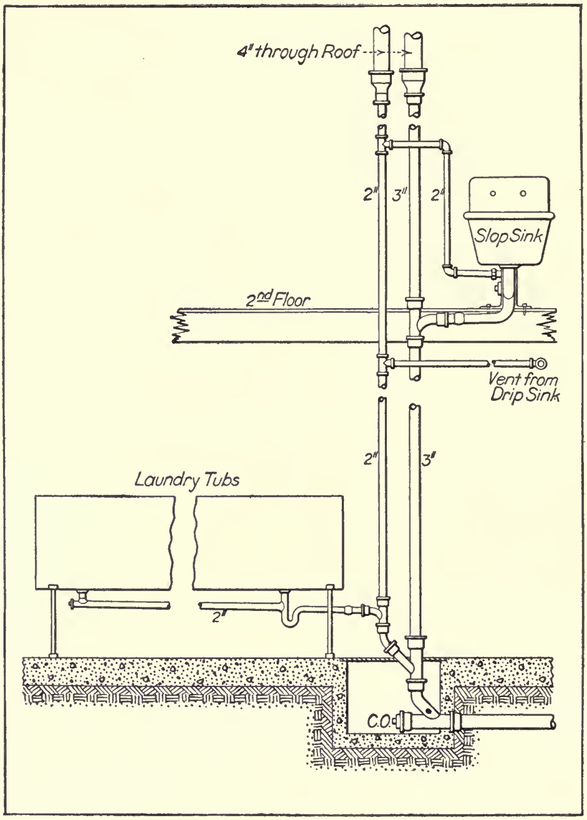


FIG. 216—ELEVATION OF STACK NO. 6 SERVING LAUNDRY IN BASEMENT AND SLOP SINK ON SECOND FLOOR

Alternatively, and what is better still in the opinion of many sanitary engineers, the fresh-air inlet pipe can be continued to the roof level. This insures that drain odors will never be discernible and does not at all interfere with a proper circulation of air through the system.

The base of all of the risers should be supported properly. The bends used to make the turn from the vertical line to connect with the horizontal Y already mentioned should be of the long turn pattern. In the plan the stacks are seen carried in chases. This is not always done and the type of building construction used will determine its necessity or desirability. If the house is exposed to severely cold weather it may be necessary to protect the soil and waste pipes from frost when carried thus in chases in an outside wall. For this reason it may be found desirable to keep them inside of the walls and to conceal them by having the finishing wall furred out sufficiently. If this is impracticable the chases should be large enough to admit of properly insulating the pipes by asbestos or other covering. It must be remembered that while the discharge from the fixtures passes through the vertical pipe in

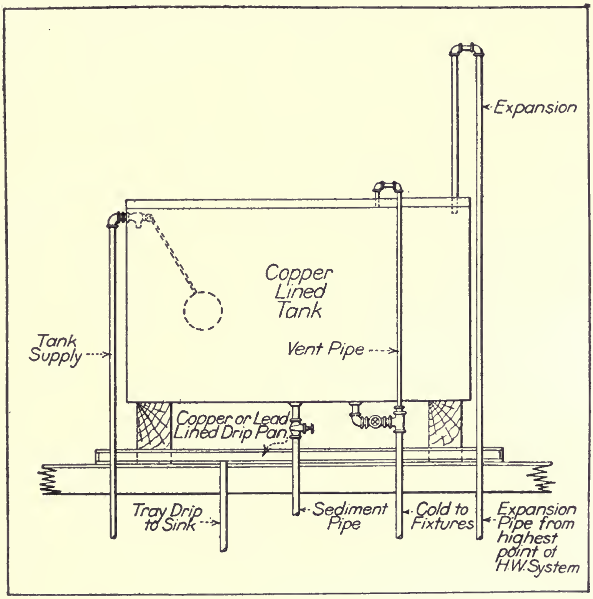


FIG. 217—CONNECTIONS TO ATTIC TANK AND ARRANGEMENT OF EXPANSION AND VENT PIPES FROM HOT AND COLD SUPPLY SYSTEM

a comparatively short time, the walls of the pipe may be brought to a very low temperature if there is a draft passing up the chase or if the frost has penetrated the outside walls sufficiently. In such a case ice may build up inside of the pipe at each discharge and so eventually stop its passage.

The elevation of Stack No. 1 in Fig. 211 is interesting, and offers a good example of the various conditions that must be looked for in a country house plumbing system. At the base the long turn bend enters a Y placed in a concrete cleanout box with an iron plate cover. A 3-in. vent pipe runs parallel to the soil pipe to the roof, and is connected into it below the lowest waste connection. This happens to be from a porcelain sink used in tending and watering the table plants in the house. The waste pipe from this sink enters the vertical pipe through a sanitary tee. A regular Y might be used, but in the vertical position the sanitary tee gives entire satisfaction. The vent pipe from the sink is a continuation of the waste pipe. It is connected to the 3-in. vent pipe at some distance above the level of the sink, and the fittings used are for the most part 45-degree ells.

The bathroom on the floor above is that of the owner. In it there are a closet of a high-grade type connected to the lead bend by a floor flange, a pedestal lavatory, a porcelain bathtub and a bidet. The latter fixture is not commonly placed in bathrooms used other than by the owner's family. On the third floor there is another bathroom with a similar equipment, except the bidet, and with an arrangement of waste and vent piping practically identical with that on the second floor. In both cases the soil and vent pipes pass up between the closet and the other fixtures. In some respects this is an advantage, as it allows of a simplification of connections.

The horizontal branch pipe for the first floor bath and lavatory connections is of 3 in. diameter. It enters the vertical stack through a Y and is continued beyond the bidet in 3-in. wrought-iron galvanized pipe. This might well enough be cast iron if space will permit of it, but the wrought-iron pipe occupies less room, and there is less danger of any leak developing such as might occur through the loosening of a calked point through the effect of expansion and contraction where much hot water is used.

The lavatory branch is vented on the continuous principle. The vent for the bidet is taken off close to the fixture branch, while the bath trap is vented from the crown. The water closet enters the main stack through a sanitary tee placed above the bathtub branch and the vent pipe, which is of 2 in. diameter, is taken from the lead bend. It is a matter of controversy as to which is the best position on the bend for the vent connection. Structural difficulties often prescribe its position on the horizontal part where it is illustrated. Where such do not exist it is doubtless better to make the connection at a point closer to the seal of the trap it is intended to ventilate and this is as a rule the point on the vertical part of the bend just below the floor level.

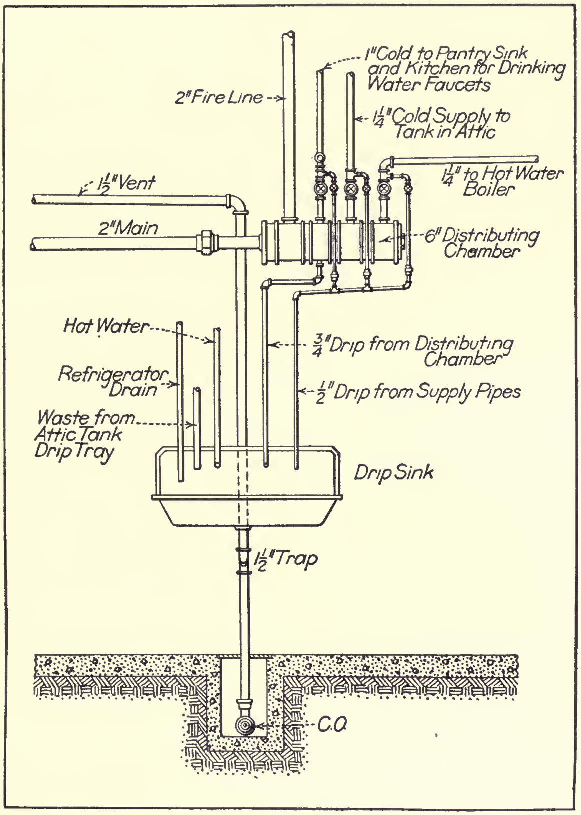

1" Cold to Pantry Sink and Kitchen for Drinking Water Faucets
2" Fire Line
1¼" Cold Supply to Tank in Attic
1½" Vent
1¼" to Hot Water Boiler
2" Main
6" Distributing Chamber
Hot Water
¾" Drip from Distributing Chamber
Refrigerator Drain
½" Drip from Supply Pipes
Waste from Attic Tank Drip Tray
Drip Sink
1½" Trap
C.O.

FIG. 218—DISTRIBUTING CHAMBER ON MAIN SUPPLY TO HOUSE WITH CONNECTIONS TO HOT AND COLD DISTRIBUTING SYSTEM AND DRIPS TO EMPTY SYSTEM

It is not necessary to ventilate the upper closet bend. It is so close to the stack that there is not any liability to self siphonage by the discharge, while the fact that it is the highest fixture on the stack safeguards it from the effect of the discharge from other fixtures. In rooms where the fixtures are arranged differently, and where the closet is on the same side of the stack as the other fixtures it may not be possible to connect the branches into two separate fittings on the vertical stack. In such a case one of the special branch fittings which has one opening for the closet and one or more for the other fixtures in the room may be used with advantage. If the closet is very close to the stack it may be advantageous to use one of the branch fittings which has a vent connection incorporated in its construction. This admits of as close construction as it is possible to obtain. The appearance and utility of these fittings may be seen in Fig. 212.

There is only one bathroom on Stack No. 2 and as it is identical with the arrangement shown on the third floor room on Stack No. 1, it is not necessary to describe that. On Stack No. 3, shown in Fig. 213, there is only one bathroom on the second floor. The toilet room in the basement is connected close to the base of the stack, however, so may be called an integral part of this elevation. The vertical stack enters the branch at the base by a long turn bend as on the others. A cleanout is placed in the end of the Y, which receives it and a 4-in. × 2-in. Y is placed at the base of the stack to connect the bottom of the vent pipe which runs parallel with the soil pipe. A double Y branch receives the toilet room fixture wastes and the waste pipe of the lavatory is continued as a vent pipe connecting into the 3-in. pipe running beside the stack. The vent from the toilet-room closet is connected to the closet bend on the vertical part and a short piece of lead pipe connects it with the iron pipe carried to a tee on the vent from the lavatory. This disposes of the vent and waste connections to this room.

As all of the fixtures in the bathroom on the second floor are in a line and at one side of the risers, a 4-in.×2-in. Y is inserted in the horizontal 4-in. line, as shown. The closet is connected through a 4-in. lead bend connected to the iron by a cast-brass ferrule wiped to the lead pipe and with a vent connection of 2-in. lead pipe wiped into the bend close to the vertical part. A 2-in. wrought-iron pipe is carried from the hub on the Y branch fitting and receives the waste from the lavatory and that of the bathtub. The trap for the bathtub is of the ordinary half-S variety and is vented from the crown by a piece of 1½-in. lead pipe connected to the iron pipe by a piece of brass pipe of iron-pipe weight, properly threaded and wiped to the lead pipe.

The lavatory is vented by a continuous connection. This is probably the best and simplest method of making waste and vent connections for fixtures set in these relative positions.

The top of the stack is finished above the roof level as shown in the detail in Fig. 214. The 3-in. vent pipe may be connected back into the 4-in. pipe before it reaches the roof if preferred, and this is done through a reverse Y branch for preference. A simpler but less effective connection may be made by means of a tee, but the 45-degree angle should be maintained wherever possible.

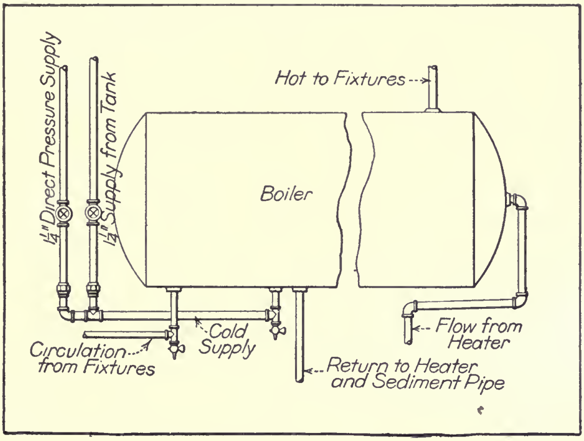

1¼" Direct Pressure Supply
1¼" Supply from Tank
Hot to Fixtures
Boiler
Flow from Heater
Cold Supply
Circulation from Fixtures
Return to Heater and Sediment Pipe

FIG. 219—CONNECTIONS FROM TANK AND MAIN COLD SUPPLY TO HOT-WATER STORAGE TANK

The roof connection shown in Fig. 213 is about as good and lasting as can be devised. It is only necessary to bring the pipe up to a point where the back part of the hub is on a line with the roof boards and then to beat a piece of sheet lead about 21 in. × 24 in. around the hub in the manner indicated. The lead is cut so that it may be turned down inside the hub to a level which will be beneath the line of the calking lead.

Then when the short piece of iron pipe which is to finish the stack is calked into place the joint between the roof flashing and the pipe is a thoroughly tight one and neither sewer air nor rain can penetrate the connection. The upper part of the flashing is carried up so that it will reach the second course of shingles or slates. Thus no rain can find its way between the joints of the roof covering and so down behind the lead. Whatever comes in then will be carried back to the outside of the flashing. If it only reached to the first course there would be a chance of leakage in windy weather especially. The lower part of the lead is carefully dressed over the courses of slate beneath the line of the pipe, and it is always well to get these flashings in before the slates are placed, so that the sides may be protected also by the slates. If they must be put on over the shingle or slate the lower edge of the flashing should be turned back beneath the lower course and dressed down tightly. This will prevent the edges from being blown up in a wind. The part around the hub need not be dressed closely in unless for good appearance. A good workman can dress the lead so that it will fit the hub closely, but a certain amount of care is necessary to prevent thinning the parts unduly and so weakening them at a vital point.

The kitchen fixtures are served by Stack No. 4. As there are only two sinks on the line it is made of 3 in. diameter cast iron. Any larger size is unnecessary and would, in fact, be a disadvantage, as it would not flush so thoroughly, and there would be some liability to collection of grease on the walls of the pipe. The connection at the base of the stack is made as previously described. The vent and waste connections to the vegetable and dish-washing sinks are as simple as possible, and the traps are connected back into the vertical branch connections so as to afford a continuous vent connection.

The fact that there is more liability to stoppage of the waste pipes at this point than at any other in the system should be borne in mind when arranging the waste lines. If a cleanout is left at the end of the horizontal line catching the wastes from the two sinks access will be easy when necessary, but it is better also to provide grease traps with water-cooled jackets so that the grease will be solidified in the traps and held for removal from time to time.

Such traps are illustrated in the sectional elevation of Stack No. 4 in Fig. 215. They are of various sizes to suit the needs of the house, but are always provided with large cleanout tops, easily detached, yet providing gas-tight joints. The water supply to the sink is caused to circulate around the jacket before it is connected to the faucet.

The vegetable sink may be of any material preferred, but satisfactory results are given by those constructed of galvanized cast iron and these are commonly used. The provision of such a fixture is a great convenience in a kitchen where much cooking is done. In some cases it may be preferable to install it in the cellar, but this is a matter for individual preference to decide. It may be recommended, however, for general use, as it allows of the regular sink being kept free for use in drawing water or in washing dishes while the other is in use in the preparation of the food.

A pantry sink is all that is served by Stack No. 5, while No. 6 serves the laundry tubs in the basement and a slop sink on the second floor. The vent pipe is carried up from the laundry tub waste connection and receives the vent pipe from the drip sink in the laundry and also the re-vent pipe from the slop sink before it is carried through the roof. It is increased in size to 4 in. a few feet below the roof line, and is flashed with lead as previously described. The waste line from the slop sink is also 3 in. in diameter, and is increased to 4 in. at the same level as the vent line. The slop sink is connected by means of a lead bend and a cast-brass ferrule. The waste pipes from the laundry tubs are connected into a common trap of the half-S variety. The short pieces connecting the tub outlets with the horizontal pipe are branched in at an angle so as to facilitate the flow. The details of this stack are shown in Fig. 216.

Riser No. 7 serves a bathroom on the second floor identical with the others in equipment, and also the vent pipe from the photographic room equipment. The connections are made as previously described for fixtures of a similar nature. The sink is of enamelled iron supported by concealed hangers and the lavatory of a substantial wall pattern with round front and high back. Wooden drip trays are procided at the sink in preference to enamelled iron, this being for greater safety and protection against breakage of glasses and bottles when setting them down in the subdued light necessary in that room.

The water supply to the building is by gravity from a spring. There is a collecting reservoir at the spring and in addition a storage tank in the attic. The connections to this latter are seen in Fig. 217. A copper-lined tray is placed beneath the tank to take care of any condensation or leakage, and a waste pipe from here is taken to the drip sink in the basement. The tank is of wood built up in sections of about 1 in. thick by 2 in. wide, the ends lapping alternately. The supply to the fixtures is taken off in such a manner as to provide for vent when the valve is closed. Thus the pipe may be drained completely, as no water will hang in the pipe through lack of air. A sediment pipe is also provided whereby the tank may be flushed out periodically. This is connected to one of the rain water leaders, which is carried to the outside drain serving these in cast iron. Thus there is no connection with the sewer system, while the water is carried away satisfactorily when it is necessary to wash out the tank.

The connections where the main supply pipe from the spring enters the building are shown in Fig. 218. A 2-in. galvanized iron pipe conveys the water from the spring reservoir and this supplies some outbuildings before it reaches the house. A gate valve is placed in a hydrant box just outside the wall of the house, so that the supply may be closed off when necessary by those having authority, but avoiding the risk of accidental closing such as might obtain were it placed inside. The reason for the safeguarding of this point is that a fire line is provided and there is, of course, no valve between the main and the hose connections in the halls of the house. Therefore, the extra provision on this score, as the water is then immediately available if necessary.

A 6-in. distributing chamber is used at the point where the various connections are made. This ensures an ample supply to each branch and a favoring of no one at the expense of another. The chamber is made up of tees with short nipples between and the ends are caps, one of which is tapped to suit the 2-in. pipe, while the other is closed with a plug. It is placed over the drip sink in the laundry and the connection to the drip sink faucet serves also as a drain for the distributing chamber should the water be shut off the house and the pipes drained. Tees are placed behind the control valves on the various lines and drip pipes connected back from these also, as shown.

A connection is taken directly from the chamber to the hot-water boiler and the connection there is made as shown in Fig. 219. This provides a means of filling the boiler should the tank in the attic be empty for any reason, although at all other times the supply will come from that tank. The illustration in Fig. 219 also shows the method of making the flow and return connection to the heater and to the fixture supply loop. The method of circulating the hot water is extremely simple. A flow pipe is carried direct to the attic and at the highest point a vent pipe shown in the elevation of the tank connections in Fig. 217 is placed. Then the flow pipe is carried around the attic and at the proper points the branches for the various bathrooms are taken off and dropped to the basement. The connections to the loops in the attic are made from the under side of the pipe and a valve is placed on each branch.

A valve is also placed at each return connection to the corresponding return loop in the basement, and these are checked down so as to maintain the circulation in the branch only sufficiently to balance up the system. Thus the supply to the farthest away fixture is drawn as quickly and at as high a temperature as those nearer the boiler.

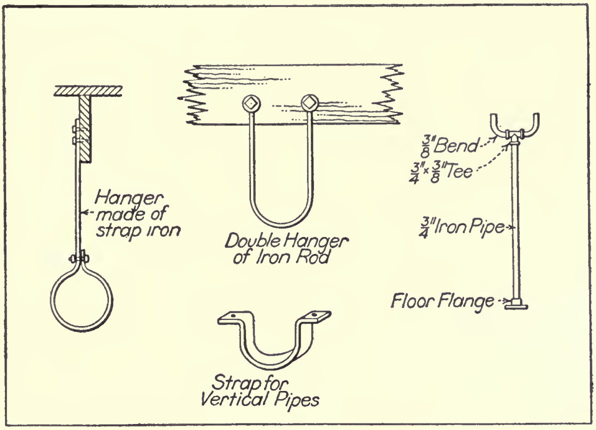

Hanger made of strap iron
Double Hanger of Iron Rod
$\frac{3}{8}$" Bend
$\frac{3}{4}$" × $\frac{3}{8}$" Tee
$\frac{3}{4}$" Iron Pipe
Floor Flange
Strap for Vertical Pipes

FIG. 220—TYPES OF SOIL PIPE AND SUPPORTS

In a building of this nature, where the runs are comparatively long and the height inconsiderable, this system is preferable, if it is at all possible to install the flow pipe in the attic. If it is feared that damage might result from condensation or leakage of the pipes, gutters can be formed beneath them where they cross the ceilings of the second floor rooms. It is sometimes done where a particularly expensive finish is provided in rooms over which pipes are carried and does not call for any great expense.

Connections should also be made to some fixtures for the supply of drinking water direct from the spring. As a rule the pantry and kitchen sinks are provided with special faucets for this purpose, and occasionally drinking water faucets are provided in bathrooms also, besides the regular cold water supply from the attic tank. The outlet of such faucets may be bushed down to provide a smooth running stream without trouble, and this is always appreciated.

Various types of soil pipe hangers and supports are illustrated in Fig. 220. These are made of iron pipe, band iron and rod and are generally fastened with lag screws.

CHAPTER XIX

INSTALLING PLUMBING IN OLD BUILDINGS.

When a plumber is asked to install a new bathroom on the third floor of an unoccupied house and the bathroom is to be situated immediately over expensively furnished and decorated rooms which are not to be disturbed in any way the problem put up to him for solution is to say the least a hard one. That there is a way out, however, in practically every case is indisputable, for the problem is not uncommon, and to the credit of the plumber's intelligence and skill the work is generally done to the satisfaction of all.

Such a problem was encountered in the installation of plumbing shown in the accompanying plan. The house is one of the Colonial type of residences which had previously been remodelled for use as a summer home and is occupied between the months of May and September. The bathroom was installed to give additional chamber accommodation on the third floor and was only to be used at times when a more than usually large number of guests were to be accommodated. Therefore, the question of installing the plumbing in such a manner as to be absolutely safe from the effects of frost did not have to be considered. If the house were occupied at any time when there was a possibility of pipes freezing, the water could without any serious inconvenience be shut off from the room. This made it practicable to follow the method of installing the work that was adopted.

The room was built out in the attic so that a height of 7 ft. to the ceiling was secured and this was extended out as a wide dormer window with a pitched roof. So that it would not be necessary to cut into the floor joists in order to bring the waste pipe to the various fixtures, and in fact, this would have been impossible owing to the space between the ceiling of second floor rooms and the third floor being already pretty fully occupied with vent pipes from the bathrooms on the floors below, it was decided to carry these pipes above the joist level, raising the level of the bathroom floor 6 in. to gain sufficient space for pitch. Difficulty was encountered here as it was found that it would be impossible to raise the doorway and secure a practicable step down to the passageway outside the room. This was arranged for by dropping the raised part of the floor after crossing the line of the water closet, thus making a platform half way across the room 6 in. high.

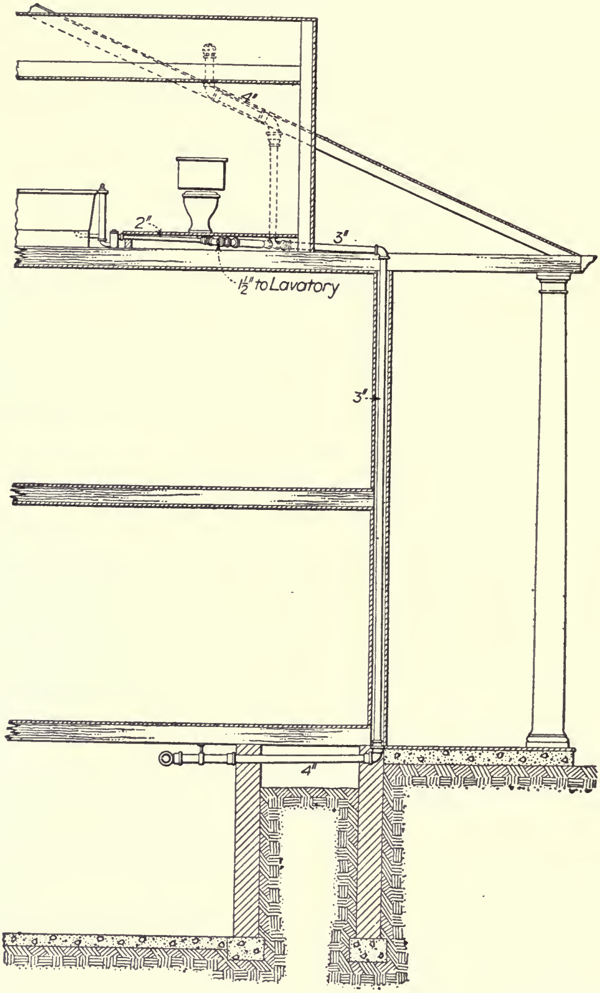


FIG. 221—SECTION SHOWING SOIL AND VENT LINES INSTALLED AFTER HOUSE WAS COMPLETED

The manner of installing the soil and supply pipes so that it was not necessary to interfere with the decorations of the room is shown in the sectional illustration in Fig. 221. The clapboards on the outside wall were removed and the sheathing cut out between two studs from the roof to the piazza floor. Then a hole was drilled through the two stone walls shown in the basement plan large enough to admit of pushing the pipe with the bend already calked in it into position. Connection to the soil pipes in the basement was easily enough made with the use of a Sisson insertion piece and the soil pipe was carried through in 4-in. cast iron to the base of the vertical stack. Into the bend at the base was calked a 4-in. × 3-in. reducer and from that point the rest of the soil and waste pipe was galvanized wrought iron. The basement work is shown in Fig. 223.

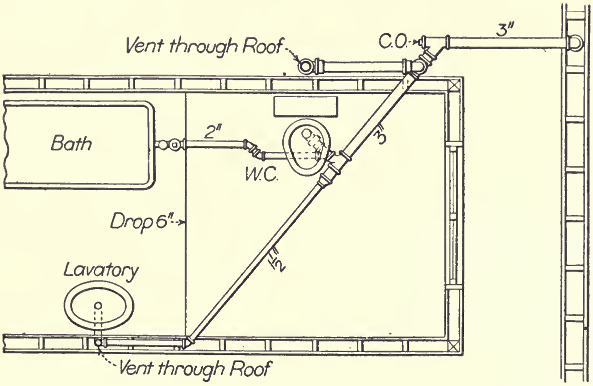


FIG. 222—PLAN OF EXTRA BATHROOM INSTALLED ON ATTIC FLOOR

The vertical stack was put up in one length, the elbow being made on before the pipe was pushed up between the joists of the third floor, which as may be seen project beyond the line of the outside wall and are supported on columns. The sheathing was cut out only up to the line of the cornice and the pipe pushed up between the lath and the cornice at this part. This required a little care and manipulation of the pipe, but avoided a great deal of work and possible damage in removing the cornice. From the attic floor plans in Fig. 222 it will be seen that a cleanout was provided at the end of the horizontal pipe running between the floor joists and that the vent pipe was connected at this point also. The vent pipe was carried up the roof a few feet to keep the outlet sufficiently far from the windows to avoid any chance of nuisance from odor.

The 3-in. pipe was connected into a 4-in. × 3-in. reducer which was calked into the 4-in. pipe and the vent was taken through the roof in 4-in. cast-iron pipe, the connection at the roof line being made with sheet lead. The water closet branch was connected to a Y on the 3-in. line which was then above the old floor line. The bath waste pipe connected to a 3-in. × 2-in. Y which was placed on the closet branch at its connection with the 3-in. line.

A 4-in. lead bend reduced gradually to 3 in. and wiped to a nipple made the connection to the iron pipe while the bath trap was of cast-brass, nickel plated and designed to be placed above the floor level as shown in Fig. 221. The lavatory waste connected with the end of the 3-in. horizontal pipe by a reducing fitting and was carried up through the roof as a continuous vent enlarging as it did so to 4 in. and passing through the roof with a sheet lead connection as previously described. The lavatory trap was of brass in iron-pipe size and connected to the sanitary tee on the vertical pipe as shown on the third floor plans.

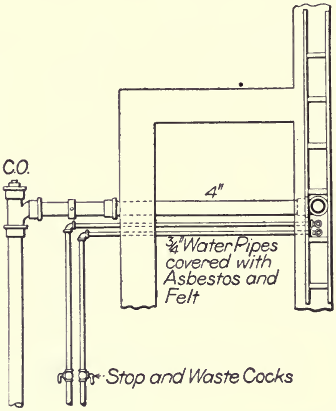


FIG. 223—PLAN OF CONNECTIONS IN CELLAR

Thus the soil and waste pipes were put in without any difficulty and the water pipes were fitted alongside the soil pipes. These were very carefully pitched so that they would drain back to the stop and waste cocks in the cellar and special pipe covering was used to protect them from the cellar to a point well within the new bathroom.

The 3-in. pipe has proved satisfactory in use and there seems to be no reason for hesitancy in adopting this size for a soil pipe for a single bathroom. The firm that installed the work illustrated claims that it has used 3-in. pipe for a number of years in jobs where the use of 4-in. would have made alteration of the building necessary. If the pipe ends are carefully reamed and proper sanitary fittings used, there is just as good service given as there would be with the larger size.

Installing Additional Bathroom in Country Hotel.

In order to meet the demand for more rooms with bathrooms attached, the proprietor of a country hotel made some alterations to the top floor of his building, installing three fixtures in a small room, which, with some rearrangement of partitions, was made to serve either as a bathroom connected with a suite or with a single room on the other side. As the whole hotel had only a short time before been nicely decorated, the plumber who was employed to install the new bathrooms was asked to devise a way by which the necessary pipes could be carried to the basement without doing damage to the walls on the floors below.

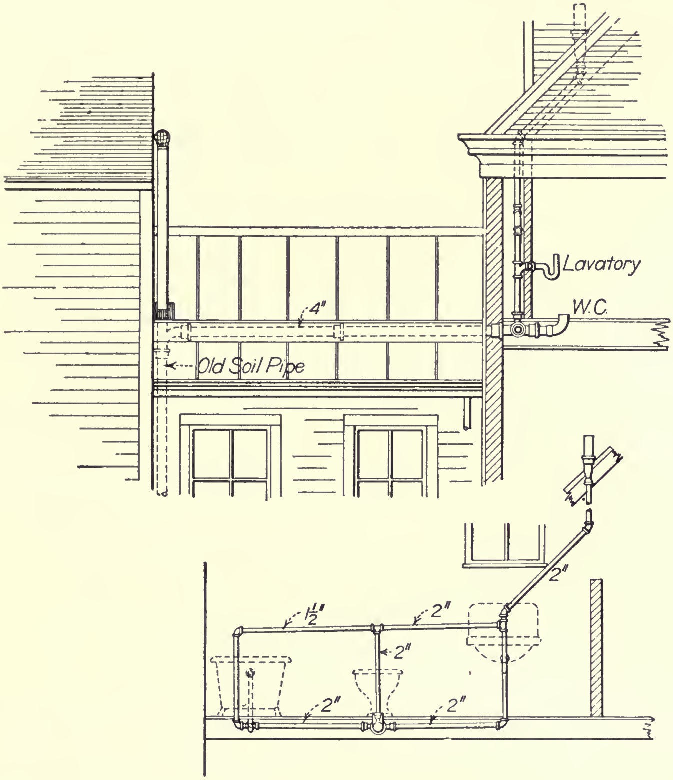


FIG. 224—DETAIL OF ALTERATION TO PLUMBING IN COUNTRY HOTEL

That he was able to do so is shown by the accompanying illustrations which show the location of the room on the upper floor of the four-story hotel and the roof of a lower building connecting an older wing also of four stories. It was seen on making an examination of the existing plumbing work that it would be very difficult to erect a soil and vent stack in the newer building as there was no place in the rooms on the floors below in which the stacks could be run without being an eyesore. Therefore, a careful examination of the older building was made and it was found that a 4-in. soil stack serving a number of toilet rooms in the lower building connecting the two main wings of the hotel was situated so that a connection might be made if only the height of the floor of the room in which the new fixtures were to be placed would permit it. On close examination it was seen that the levels were such that the connection would either have to be made above the roof line or a pipe would have to be carried across the ceiling of a hall on the top floor of the low building. This was not considered advisable for several reasons so it was decided to adopt the alternative method and to make the connection with a sanitary tee as shown in the illustration in Fig. 224.

There were several advantages in this method, not the least of which was the fact that a hub which was finished with the roof line so as to secure a flashing around the stack was in exactly the right position for the new bathroom connection. It was an easy matter to cut the stack above this hub and to dig out the lead and oakum so that the soil pipe was ready to receive the new branch. It may be mentioned here that the vent connections from the fixtures on the floors below did not return into this 4-in. pipe, but were carried out through the roof in a separate vent line. This was fortunate as otherwise some alterations of a difficult nature would have been required.

The location of the three fixtures is seen in Fig. 225. The lavatory basin is situated under a window, the closet directly in line with the soil pipe and the bathroom along the front wall of the building. This location enabled the plumber to simplify the piping considerably as a double Y with a side inlet was used for the connection to the bath and the lavatory, the side inlet serving as a vent pipe for the water closet bend. While the vent connection was farther away from the closet trap than is desirable, it was considered that as there were no fixtures on the line except the bath and the lavatory the closet trap would be perfectly safe against the effect of pressure of air from the discharge of either and that there was little fear of the trap being siphoned.

In any case the fitting was used and it has proved satisfactory in use. In Fig. 226 the elevation of the waste and vent lines is seen. It will be noted that in order to clear the window under which the lavatory is placed it was necessary to offset the vent pipe after the connection from the bath and W. C. vents had been made. This was done by 45-degree fittings and the pipe was enlarged to 4 in. before it passed through the roof. The roof connection was made of sheet lead carefully beaten around the hub and pushed up below the shingles until it reached the second course above the pipe. The vent pipe was carried up until it was safely above the height of the roof windows so that it would be unlikely that any odor would ever be distinguishable therefrom.

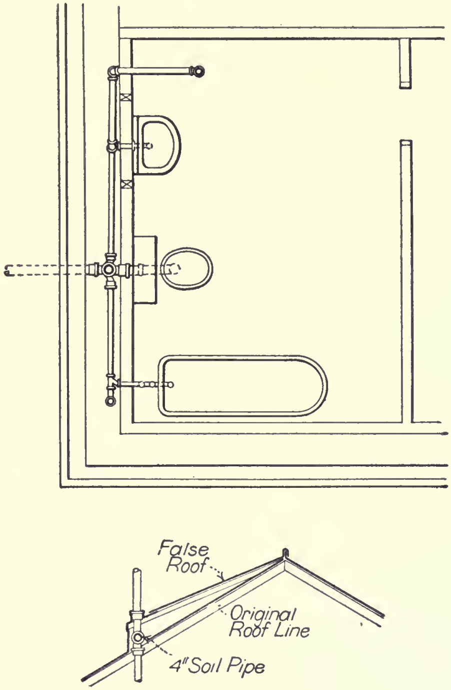


FIG. 225—PLAN OF NEW BATHROOM AND DETAIL OF ROOF CONSTRUCTION

In order to cover the pipe and protect it from the effect of frost where it crossed the roof of the connecting building, a false roof was constructed. This is shown in section in Fig. 227 and was simply put on over the top of the other without removing the tin. At the front of the pipe, where the upstand necessary to requisite height of 9 in. The sheets were simply cut back of the line of the box 9 in. and turned up and then the sheathing was accommodate it occurs, however, the tin was cut and set up for the nailed in position and the upstand fastened to it. A lock seam was turned where the tin on the false roof joined the upstand and as the seams were of the standing-lock variety these were turned over a little above the edge of the false roof and flattened down to make a secure and water-tight connection at the upstand. A block of wood sawed to an angle was placed below the hub of the first length of 4-in. pipe and also beneath the second length to support them. The pitch given was ample as the depth of the false roof could be made anything that was desired.

The pipe was well wrapped with hair felt before the roof was put over it and at the place where the 4-in. vent stack passed through the false roof a copper flashing was put around the pipe and dressed down into the hub before the extension piece was calked into it. This afforded a secure flashing which could be securely soldered to the tin roof. The water-pipe connections were easily secured as they were made to the hot and cold-water risers serving the fixtures in the connecting building and were brought up in an inconspicuous manner in the hall before mentioned. The pipes were left bare but were decorated so as to harmorize with the woodwork in the hall and were kept into the corner as much as possible.

Control stopcocks were placed on the branches and in addition valves were placed on the supplies at the lavatory, closet and bathtub. The job has been in satisfactory use for a number of months and has passed successfully through one winter which, although not especially severe, was, on several occasions, cold enough to afford a satisfactory test.

Inserting a Header to Make Room for Connections.

Occasionally some difficulty is encountered in the installation of plumbing in old buildings through the primitive type of building construction used. When the joists prove to be of the split-log variety and in addition it is necessary to cross them in order to reach the position at which the soil pipe or waste pipe must be placed, some ingenuity must be exercised in order to find a way out of the difficulty.

Such a condition is illustrated in the plan of a bathroom shown in Fig. 226. This bathroom is on the second story of an old farmhouse remodeled for the summer home of a well-known scientist and the joists, while not merely split logs, are axe-hewn and only 6 in. deep. They are, however, 3 in. wide, so make up somewhat in width what they lack in depth. The house is of the usual heavy framed type commonly built about 100 years ago, with framing timbers about 8 in. × 8 in., upon which the joists of the second floor rest. The only position possible for the soil pipe is in the corner of the bathroom and the desired location of the fixtures is indicated by the dotted lines in Fig. 228.

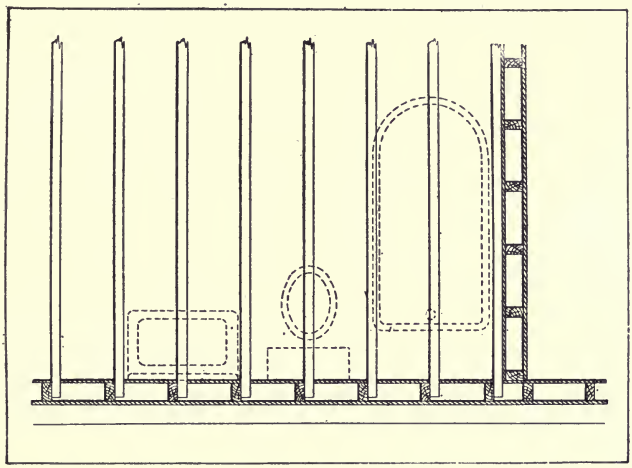


FIG. 226—PLAN OF FLOOR JOISTS IN ROOM WHERE FIXTURES WERE PLACED, SHOWING DIFFICULTY IN ARRANGING RUNS OF WASTE LINES

Locating the fixtures in this fashion, as may be seen, required that the soil pipe connection to the water closet should cross three joists. As the room was plastered and it was desired that as little damage as possible be done to the finish, this added somewhat to the difficulty in that it made it imperative to find a way of ventilating the fixtures without carrying the vent pipes in this wall. The room behind the new bathroom, however, was an unimportant one and it was decided to carry the vent pipe through to there and then connect it back into the soil stack in the same room. Thus no pipes were seen in the new bathroom and no plaster, excepting in the corner behind the bathtub, had to be broken.

No carpenter was available to make the structural changes which were required in the floor joists to admit of the fixtures being placed as indicated, and as this was the only feasible location, preparations were made by the plumber for the insertion of a header at a point which would allow the closet to be connected and the bath trap placed without the need of cutting into joists. First of all, the ceiling of the first floor was shored up so that when the joists were cut they would not sag unduly. This was accomplished by placing wide boards on the ceiling and floor below and driving vertical posts in so that they wedged tightly between the floor and ceiling boards. Then the joists were cut out, taking great care to remove them gently so that the laths would not be disturbed with consequent breakage of plaster. When these had been removed the header was cut and placed in position.

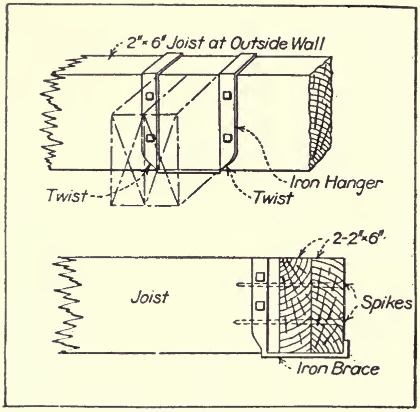


FIG. 227—IRON HANGERS USED TO STRENGTHEN HEADER

So as to provide a secure support for the header iron saddles or hangers of the shape shown in Fig. 227 were made and those on the supporting joists placed before the header was put into its place. These were made from bar iron 1¼ in. wide and ¼ in. thick. They were twisted so that they would lie with the flat surface where the header rested in them, and as they turned over the top of the joists they afforded a good support for the header and consequently it was not necessary to depend entirely upon the spikes with which it was fastened to the joists. The headers consisted of two 2 × 6-in. joists.

When the header had been laid into its end supports and fastened at each end it was found that the floor sagged a little in the center. No screw jack was at hand to help in this difficulty, but the sagging was corrected by wedging up the timbers on the floor below. Then two large screw eyes were fastened into the joists above and a length of heavy jack chain passed through these screw eyes and over a timber laid on a carpenter's horse, the legs of which were supported on the framing timber at one side and on the whole joists on the other. Then by inserting a pin in the jack chain and twisting it, the sunken joists were readily raised to the right level and the saddles inserted. When the header was finally fixed by spikes driven into the joists the place was ready for the pipes.

It was seen that it would be difficult to vent the closet bend or the bath traps satisfactorily, as it would be necessary to cross the soil pipe to reach the vent pipe, so a drum trap was used for the tub and the closet was left without a vent, trusting to the short branch connection to protect the seal sufficiently. The pipe was carried in 4-in. cast-iron pipe to the closet connection, where a reducer was placed in the Y and the rest of the pipe to the lavatory was carried in 1½-in. galvanized wrought iron pipe. Recessed fittings of the drainage type were used. The pipe passed through

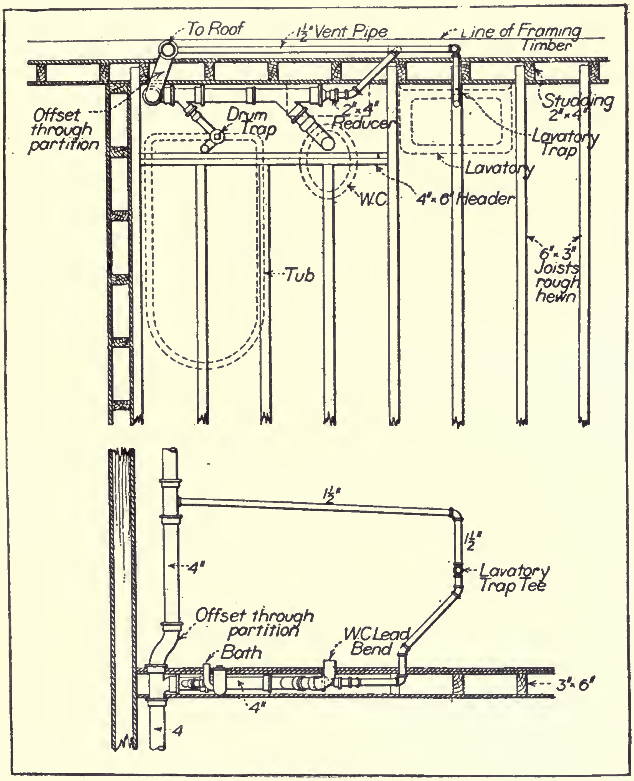


FIG. 228—PLAN AND ELEVATION OF BATHROOM PIPING, SHOWING HOW HEADER ALLOWED CONNECTIONS TO BE MADE WITHOUT CUTTING INTO JOISTS

the wall in the space made by the header so as to avoid the necessity of cutting the first joist beyond it, and then it was offset to the position required, using 45-degree fittings.

The lavatory connection was made to the vertical pipe by a regular basin tee and then the vent pipe was connected back into the soil stack which had been brought through the wall immediately above the closet branch. The soil stack was carried through the roof in the usual manner, while the soil pipe was connected with the rest of the house drains in the basement. The method of connecting the various fixtures is shown in plan and elevation in Fig. 228. While this method of connecting the fixtures is simple in the extreme and does not provide the vent connections usually called for, it is perfectly good practice in the particular conditions shown, as there are no fixtures above these and no tendency to siphonage or forcing of the seal of any of the traps can be noticed under any conditions of use.

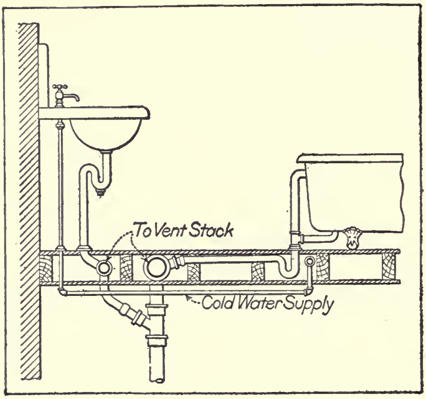


FIG. 229—UNSATISFACTORY METHOD OF CONNECTING WATER PIPES TO CROSS WASTE CONNECTIONS

Cutting out the joists as is indicated in the plans necessarily means that the laths must support the plaster on the ceiling below without any support between the header and the wall, but as they, in an old building of this type, are generally of the sawn variety and very heavy, they are generally capable of doing this without any noticeable sagging of the ceiling. To relay the floor in the bathroom, however, it is necessary to provide support for the flooring, and this is done by nailing cleats to the framing timbers. It may be necessary to leave out some of the rough boards beneath the finished floor where the hubs occur if the joists are only 6 in. deep.

In the job in question the supplies to the fixtures were carried along the baseboard of the bathroom so that no provision had to be made below the floor for the accommodation of hot or cold supply pipes. Had it been necessary, however, it would have been easy enough to have connected these so that they would not be trapped at any place if the supply had come from the basement. In this case the hot and cold pipes were carried in the room behind the bathroom and through the wall to the baseboard, then to the fixtures.

To support the lavatory basin, which was of the deep apron, high back, white enameled variety with concealed hangers, the plaster was cut out behind the place where the lavatory back would be and a heavy board set in and firmly nailed to the studding. The same was done for the support of the water closet tank, and care was taken to proportion these so that no plaster would be cut outside of the line of the fixtures. The soil pipe, where it passed through the room below the bathroom, was boxed in a corner and decorated so as to be inconspicuous.

Location of Water Pipes in Old Buildings.

When it is necessary to install waste and soil pipes below floors in old buildings it sometimes happens that the joists are so shallow that the entire available space is occupied with those pipes and difficulty is experienced when it is necessary to cross them with the water supplies. The method illustrated in Fig. 229 where the water pipe is carried through the ceiling of the floor below the bathroom is sometimes adopted but if a very low pressure of water is available it sometimes leads to trouble. Besides leaving a trap which cannot be emptied without some difficulty should that be necessary it affects the flow of water at the faucets and if it is impossible to cross the soil pipe below the floor the system should be planned so that either all of the pipes are carried on the ceiling or wall of the room under the bathroom or the pipes should be carried on the baseboard of the bathroom. This may be done in a very neat manner with iron pipe or if a superior job is desired in nickel plated brass pipe.

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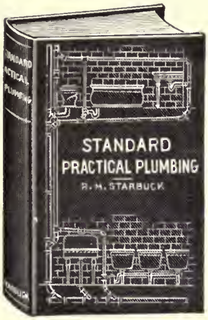

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